

Prototype Computer-Interactive Groundwater
Monitoring Methodology: An Example for
Sedimentation Ponds

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Prepared for

Environmental Monitoring Systems Lab.
Las Vegas, NV

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**A PROTOTYPE COMPUTER-INTERACTIVE
GROUNDWATER MONITORING METHODOLOGY:**

An Example For Sedimentation Ponds

by

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16. ABSTRACT This report describes a prototype computer-interactive system that assists the development of a groundwater monitoring program for sedimentation ponds at coal strip mines. Even though the monitoring of sedimentation ponds is used as an example, the system consists of a set of instructions applicable to monitoring any specific groundwater pollution source. The instructions enable the user to select from a large amount of text information those portions appropriate to be written into his own file. Of the several approaches that can be used, the approach described in this system is one which breaks the text into segments or frames numbered consecutively and stored in a sequential file. The information contained in the frames offers various alternative methods for building components of a mine surface and subsurface water monitoring design plan. The user constructs his own monitoring design file by selecting from the methods presented those applicable to his specific mine. For each step and objective the user is presented with a description of the principle involved in each of the alternative methods, the advantages and disadvantages of each, and the associated cost.		
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PREFACE

Protection of the environment requires effective regulatory actions based on sound technical and scientific data. The data can include the quantitative description and linking of pollutant sources, transport mechanisms, interactions, and resulting effects on man and his environment. Because of the complexities involved, assessment of exposure to specific pollutants in the environment requires a total systems approach that transcends the media of air, water, and land. The Environmental Monitoring Systems Laboratory at Las Vegas contributes to the formation and enhancement of a sound monitoring data base for exposure assessment through programs designed to:

- o Develop and optimize systems and strategies for monitoring pollutants and their impact on the environment
- o Demonstrate new monitoring systems and technologies by applying them to fulfill special monitoring needs of the Agency's operating programs.

This report presents a prototype systems version of the groundwater monitoring methodology developed by Kaman Tempo for the U.S. Environmental Protection Agency. The prototype computer-interactive systems program addresses the problem of developing a groundwater monitoring program for sedimentation ponds at coal strip mine sites. The research program, of which this report is part, is intended to provide basic technical information and a planning format for the design of groundwater quality monitoring programs for Western coal strip mine operations. As such, the study results may be used by coal developers and their consultants, as well as the various local, State, and Federal agencies with responsibilities in environmental monitoring and planning.

Further information on this study and the subject of groundwater quality monitoring in general can be obtained by contacting the Advanced Monitoring Systems Division, Environmental Monitoring Systems Laboratory, U.S. Environmental Protection Agency, Las Vegas, Nevada.

Dr. Lorne G. Everett of Kaman Tempo was responsible for the administrative and technical management of the project under which the report was prepared. The principal systems development and text organization was prepared by Dr. W.O. Rasmussen, University of Arizona, Tucson. Dr. L.G. Wilson of the University of Arizona, Tucson, made a major contribution to the technical material in the system. Dr. R.M. Tinlin, Camp Verde, Arizona, coordinated the technical input with the systematized version of the monitoring methodology.

SUMMARY

Kaman Tempo, under contract to the U.S. Environmental Protection Agency (EPA) from 1973 to 1976, developed an exemplary groundwater quality monitoring methodology. This structured cost-effective methodology was developed to assist responsible state and federal personnel to design and implement a groundwater quality monitoring program for any manmade pollution source under any hydrogeologic regime. This methodology is extensively discussed in Everett (1980). The methodology subsequently, in a national competition, was selected by EPA as the backbone upon which all Western coal strip mine monitoring and all Western oil shale groundwater monitoring guidelines may be based. The resulting research concluded that, regardless of the source of contamination under investigation, a finite number of monitoring techniques were available to assess the problem and design the monitoring program. In addition, the design, implementation, and operating and maintenance costs could be reasonably estimated by formula. Pump size, screen size, pumping rates, etc. all behave according to fundamental relationships, and as such, could become part of a system monitoring package. These conditions strongly suggested that a computer-interactive system could be developed that would lead a hydrologist through the process of designing a groundwater quality monitoring program. Under EPA contract, a prototype computer-interactive system was developed based on a groundwater monitoring methodology to design a monitoring program for coal strip mine sources of pollution. For exemplary purposes only the prototype for coal strip mine sedimentation ponds was developed. The portable terminal can be leased for \$250 per month or purchased for under \$3,000 at 1980 cost level. The individual user requires only a standard wall plug (110-120 VAC, 60 Hertz) and a telephone. A hard copy terminal that prints at one-half of the reading speed is preferred over a cathode ray tube display. The system utilizes a transportable code written in FORTRAN, requires less than 60,000 words of memory, and costs between \$25 and \$100 per day to run. Text modifications to make the system site- or state-specific can be done very simply.

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LIST OF CODES USED IN PROGRAM

ZZ	present line to user and also write to their MDF
CC	present line to user
01	text to be copied to MDF if user selects numeric "1" response to questions posed them - text also presented to user
02	text to be copied to MDF if user selects numeric "2" response to questions posed them - text also presented to user
on	same as above with numeric "n" response of user
\$\$	frame logic line - logic code (Figure 12) to be used with frame follows on this line
@@	end of frame mark - frame number follows on this line
!! on m	end of step n material - step finished - last step n frame accessed was frame m
\$\$ on m	end of step n material - step not finished - last step n frame accessed was frame m

ACRONYMS USED IN FLOWCHARTS

<u>Acronyms</u>	<u>Description</u>
TEXT.DAT	text file - data
MDF.DAT	monitoring design file - data
MDF.TEM	monitoring design file - temporary
REEDX (NBIT)	subroutine main driver
RD MDF	subroutine main driver
EXTEND	subroutine main driver
SOURCE	subroutine main driver
IFRM	specific frame number
TALK	subroutine main driver
INDEX	current frame number
AN	numeric or alpha user response
IN	numeric or alpha user response
ISW	control word flag
COPIX	subroutine main driver
IX	step number
BRANCH	subroutine main driver
IC	logic code symbol
TEXT	subroutine main driver
ISTP	currently executing step number
IBIT	extend, cover and continue
KF	current frame number
ITEM	monitoring design - temporary file
ID	frame number

SECTION 1

INTRODUCTION

In 1969, the important coal-producing states in the West (Arizona, Colorado, Montana, New Mexico, North Dakota, Utah, and Wyoming) had 36 strip mines, which averaged about 400 tons* yearly per mine. By 1972, the number of mines had dropped to 28, but the annual production had increased to about 1 million tons per mine. In 1976, there were approximately 60 existing coal mines in the Western States (excluding Washington, Texas, and Oklahoma), producing about 100 million tons annually. The Department of Energy (DOE) estimates that Western coal strip mines will produce approximately 570 million to 600 million tons from about 150 mines in 1986; 65 percent of this tonnage will come from surface mining, of which 70 percent will come from the West, with Wyoming being the biggest contributor.

In response to the high priority placed on Western coal development, the U.S. Environmental Protection Agency (EPA) awarded a 5-year contract to develop groundwater quality monitoring recommendations for Western coal strip mining. The purpose of this report is to present a prototype of an interactive system that could be used to assist in the selection of monitoring methods for a coal mine sedimentation pond. The approach provides for the utilization of a 15-step methodology (Everett, 1980), which includes the identification, quantification, and ranking for monitoring the important sources of groundwater quality degradation within a given coal strip mine area.

GROUNDWATER MONITORING METHODOLOGY

The computer-interactive monitoring methodology presented in this report follows a systematized eight-step procedure. This methodology has evolved from the earlier fifteen-step approach. The eight steps used in this study are based upon Table 1.

The EPA in 1979 identified coal strip mining in the Western United States as a major potential source of groundwater quality degradation (Everett, 1979). Specific sources of potential pollution were identified within this major classification. These sources are listed (Table 2) in priority order, i.e., in relative order of the magnitudes of water quality impacts that are caused by these sources in typical coal strip mining environments. Some or all of these potential sources of contaminants may be found when conducting a Step 2 inventory at a coal strip mine in the Western United States (Table 1).

*See Appendix C for conversion to metric units. English units are used in this report because of their currently common usage in industry and hydrology-related sciences.

Table 1. Tempo systematized groundwater monitoring methodology.

-
- Step 1. Select area for monitoring
 - Step 2. Inventory potential pollution sources
 - Step 3. Identify potential pollutants and methods of disposal
 - Step 4. Identify groundwater usage
 - Step 5. Evaluate infiltration potential
 - Step 6. Evaluate pollutant mobility in vadose zone
 - Step 7. Evaluate pollutant mobility in saturated zone
 - Step 8. Prioritize sources
 - a. List potential pollutant amounts, concentrations
 - b. Amounts infiltrating
 - c. Mobility of infiltrating pollutants in vadose zone
 - d. Mobility of pollutants reaching saturated zone
-

Table 2. Potential sources of groundwater pollution from coal strip mining operations (Everett, 1979).

-
1. Spoils
 2. Pit Water
 3. Construction
 4. Explosives
 5. Mine Solid Waste & Liquid Shop Wastes
 6. Sanitary Waste
 7. Spills
 8. Leaks
 9. Stockpiles
 - a. Topsoil
 - b. Overburden
 - c. Coal
 - d. Coal Refuse
 - e. Partings
 10. Reclamation Aids
 11. Solid Waste from Road Construction
-

From the list of potential sources (Table 2) a coal mine operator planning to use the monitoring methodology would select those found on his lease. Based on the relative significance of each potential source selected, funds would be allocated for development of an appropriate monitoring program for each source. To develop the program, Steps 3 through 7 of the methodology would be applied to each source in order of its priority or importance at the particular mine site. In developing a monitoring program existing monitoring effectiveness and related monitoring gaps for each of the existing sources are evaluated. Potential for groundwater contamination by each priority ranking of all sources is carried out in Step 8. The computer-interactive system presented in this report provides assistance in selecting appropriate groundwater monitoring methods on a site-by-site basis.

The systems monitoring program consists of the set of instructions needed to develop a source-specific monitoring program for each source identified in Step 2. However, only sedimentation ponds (Everett, 1979) have been selected for detailed presentation in this report.

For each type of source, the program discusses Steps 3 through 7 under the following headings:

1. General monitoring objectives
Specific monitoring objectives
2. Alternative monitoring approaches for achieving objectives, including:
 - Advantages and disadvantages for each alternative monitoring method
 - Sampling frequencies needed for each method
 - Analytical Methods
 - Costs
3. Recommended monitoring approach (including costs).

By following the preceding format (application of Steps 3 through 7 to each source), a user of the interactive system will be able to develop a monitoring program for implementation that is tailored to meet the needs of specific mine sources.

SECTION 2

GENERAL SYSTEMS INFORMATION

The computer program presented here addresses the problem of how to present a large amount of text to a user and allow him to select appropriate portions of it to be written to his own file. Several approaches may be used on such a problem. The selected approach is one whereby the text information is broken into a number of segments or frames. The frames are numbered consecutively and stored in a sequential file (Figure 1). As the program operates, specific frames are retrieved from the file and the information contained in them presented to the user (Figure 2). The presented material consists of various alternative methods of building components of a surface and subsurface water monitoring design plan. The user selects, from all methods presented, those appropriate for his specific mine and loads these into his own monitoring design file that is being constructed as he goes through the program. After the user has finished addressing the several steps in the monitoring design plan methodology, he will have assembled a file containing a tailor-made monitoring design plan for his mine. This developed file is termed the monitoring design file (MDF).

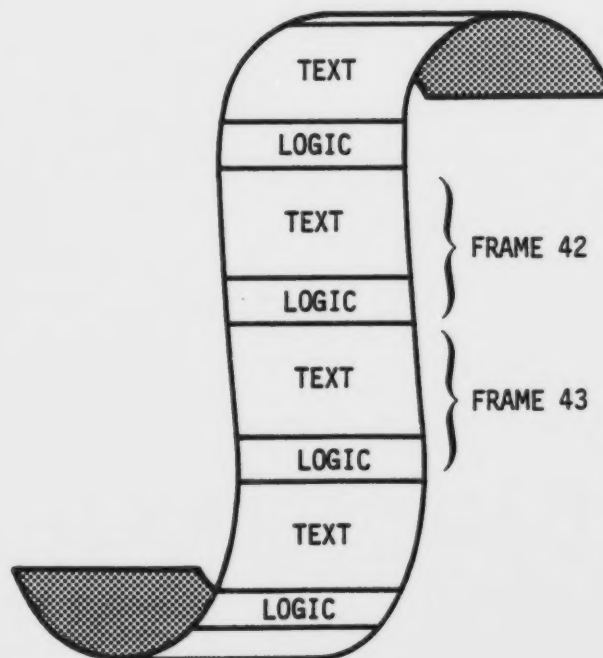


Figure 1. Typical structure of TEXT.DAT file.

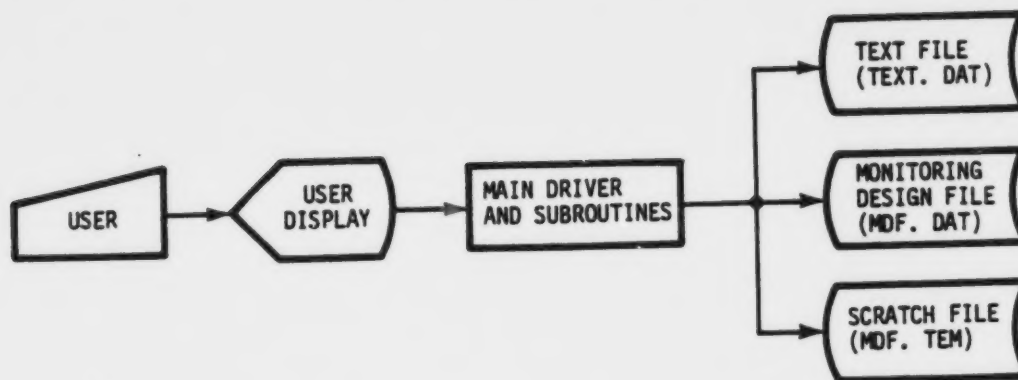


Figure 2. Basic system for program execution.

A logic record is stored in each frame. This is used by the program to determine the correct frame to branch to in response to input from the user to questions posed him regarding material in the frame itself. This dispersal of logic into the frames themselves allows a complex frame branching to occur while not cluttering the main computer program with branching information for each frame.

The program is interactive and tutorial in nature. During much of the execution, the user is presented material from a frame and then queried as to whether he would like to use some of this information in his own specific MDF; is currently using some of this material in his monitoring operations; or would like to introduce comments into his MDF. User responses to the computer program are analyzed for possible errors as well as for the occurrence of any control words. These control words require the program to override the current operation. This allows various other functions to be executed, ranging from stopping work on a specific step in the monitoring design methodology to printing what has already been loaded into the MDF.

The computer program allows the user to go through portions of the steps in the monitoring design methodology. He is not required to finish any one step before he may work on another. This allows the steps to be done in any selected order (although this is not recommended) as well as allowing a given step to be broken off and then continued from that point at a later time. Such an interruption in a step may be due to the need for data analysis, consultation with others, or the end of a work period.

The computer program is also designed to be used with either a standard or portable computer terminal. The text material is formatted such that it may be presented on a small portable terminal with 80 columns available for output. A typical terminal of this nature is the Texas Instruments 700 series, which may be easily carried and connected to any telephone. The program is operated by dialing a host computer; when a carrier signal is obtained, the telephone handset is attached to

the computer terminal. Thus, the computer terminal may be operated at any location having an electrical outlet and a telephone. A portable terminal can be leased for \$250 per month or purchased for under \$3,000. A hard copy terminal that prints at one-half of the reading speed is preferred over a cathode ray tube display. The system utilizes less than 60,000 words of memory, and costs between \$25 and \$100 per day to run. Text modifications to make the system site- or state-specific can be done very simply.

The primary text file is formatted so that it may be constructed very simply. The provided text file (TEXT.DAT) should suffice for mines in Colorado, Montana, Wyoming, and Arizona.

The computer program presented herein was developed on a DEC-20 computer, mostly through the use of ANSI FORTRAN IV so that its movement to other computers should be straightforward (see Appendix A).

A small version of the TEXT.DAT file (Section 4, Figure 14) was constructed to generate an example (Section 5) demonstrating the program's operation. In this example, various options and abilities of the program are exercised to show the reader what is available and how it may be used.

SECTION 3

PROGRAM DESCRIPTION

MAIN DRIVER

This component of the total program is used to respond to the user's request as to what is to be done for a given lease (Figure 3). It determines whether a new or old monitoring design file (MDF) is to be utilized (i.e., is this a continuation of work on an existing mine MDF or is a new file or a new mine to be developed?). It then asks the user which step he is interested in. Text material relative to that step is presented from TEXT.DAT to the user who selects appropriate items from it, and in so doing enters material into his MDF. This continues for as long as the user wishes to operate the program.

The main driver assigns device channel numbers and opens the three files that are used by the program (Figure 2). Channels are paths of information flow between the main program and the supporting files. As presently configured, the input device number is 5, as is the output device. The three files used by the program are on channels 30, 31, and 32. Since these numbers are assigned at the beginning of the main program, it allows for easy modification, if required, for another computer or configuration on a given computer. File names are also assigned to the three files. For the present case the names and functions of these files are:

- o TEXT.DAT -- the stored data file containing all the text material presented to the user
- o MDF30.DAT -- the MDF being built specifically for the user's mine site
- o MDF30.TEM -- a scratch file used to insert material into the MDF.

The program begins with the user being informed of what the program is and what it does. He is then asked if this is a new or existing lease. This question refers to whether the mine has been addressed previously by the program. If it has, the same components of the MDF for this mine already exist in the MDF30.DAT file and will be linked into the system and expanded by the current operation of the program. If the user states that it is a new mine then the program asks again if it is a new or existing mine, informing him that all information in any existing monitoring design file for that mine will be destroyed, and instructs him to input again if it is a new mine. Given that it is indeed a new mine location, the program begins to build a new MDF (Figure 3).

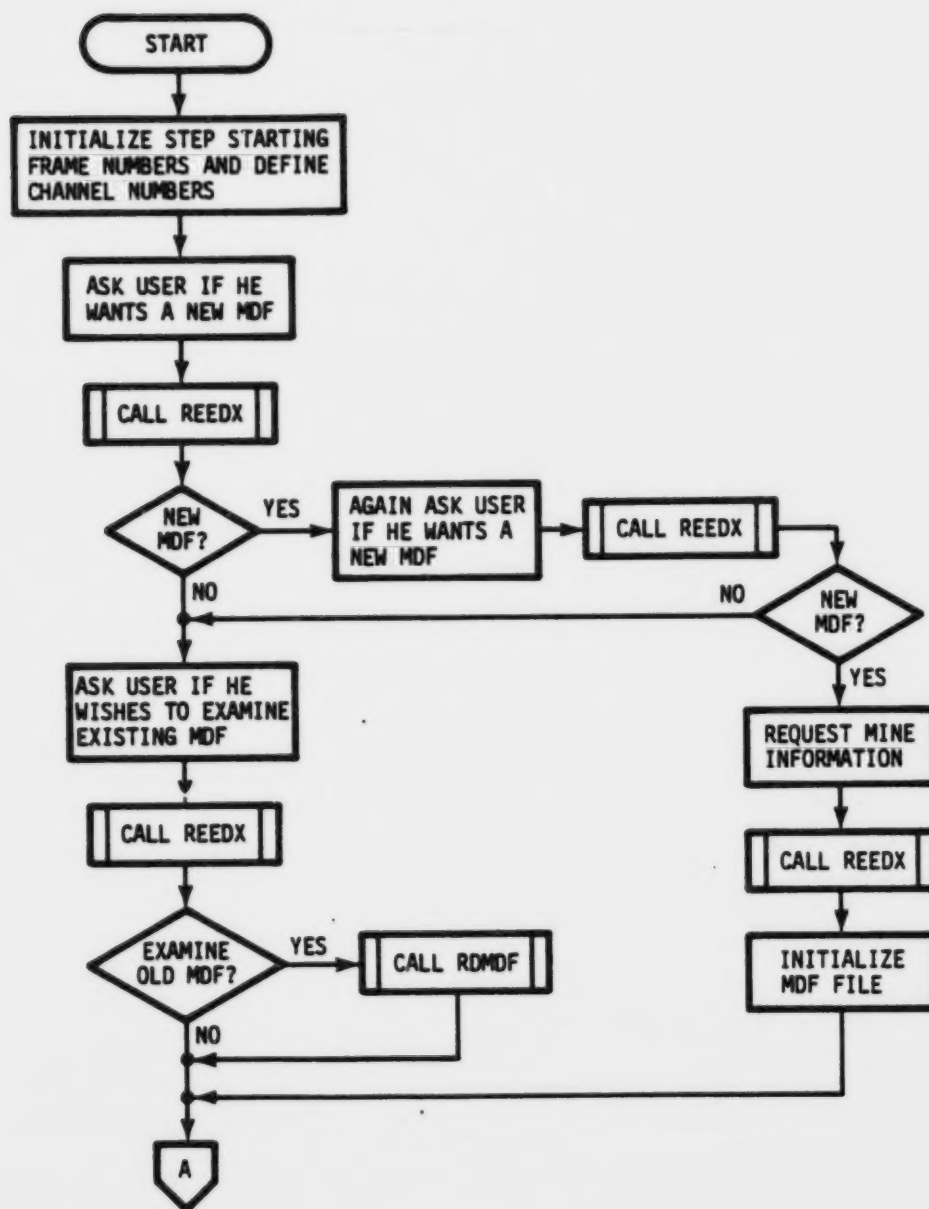


Figure 3. Flowchart of main driver.

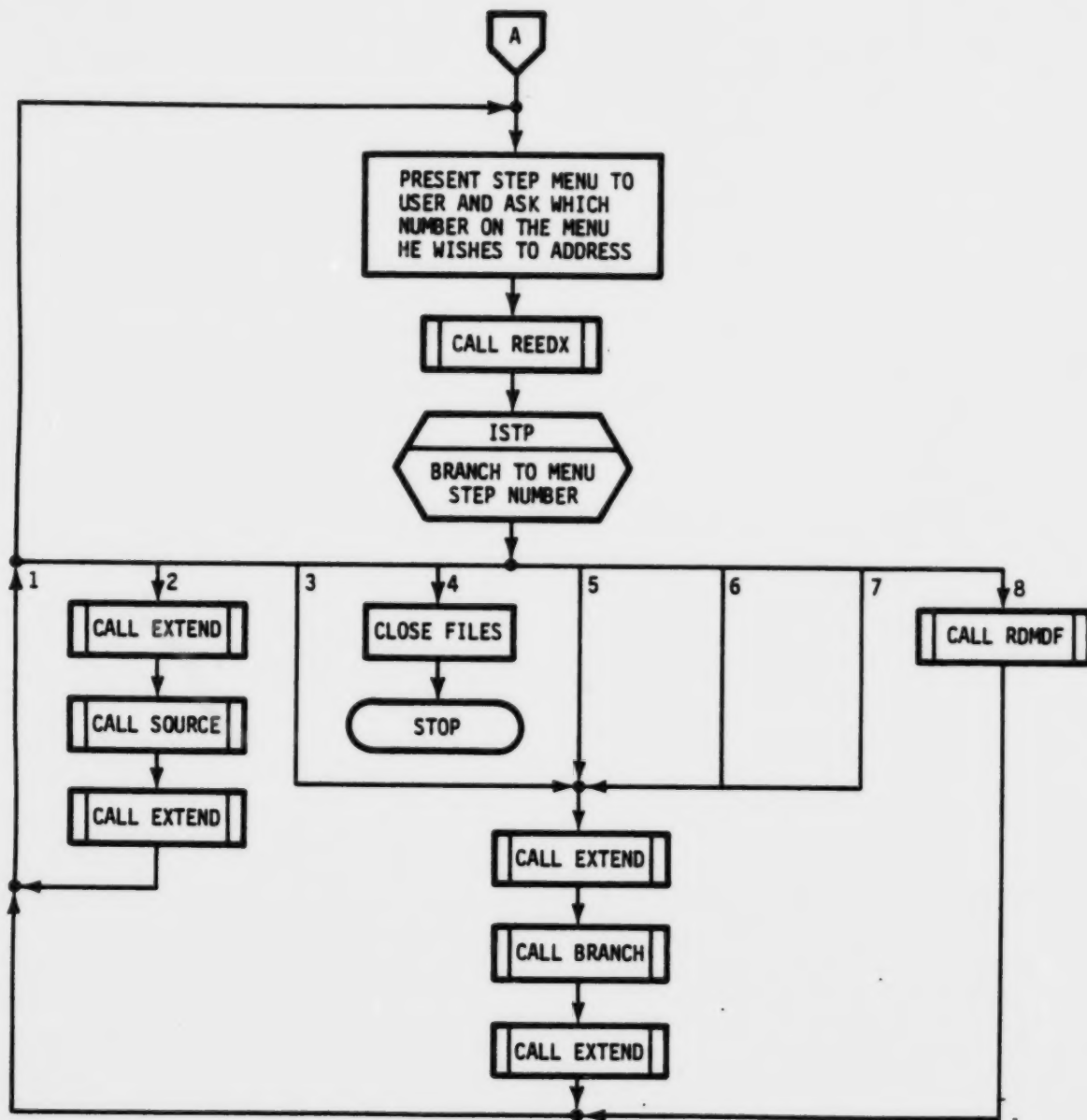


Figure 3. (continued)

To identify the mine data set, the lease number and name of the mine are requested of the user and stored as the first items in the MDF for that mine. The program then builds the rest of the file by setting up areas in which to load information relative to the several steps in the Tempo groundwater monitoring methodology. Associated with each step is a frame number in the TEXT.DAT file. This is the beginning frame of the sequence of frames containing text material for possible loading into the MDF.

If an existing MDF is to be expanded, it is first linked into the system. The user is then asked if he would like to examine its contents. In the event he does, he may look at all material stored in the MDF for a given step. This may be repeated for as many steps as he wishes. If the step has not been addressed before and is empty, the user is so informed. He is also informed if the step was terminated early and does not contain all information that it might. In a similar vein, he is informed if the step has been totally covered and the material for that step is complete. By examining the material contained in the MDF in this fashion, the user may determine the state of completion of the MDF and where he should begin for this particular session.

From either path (the initiation of a new MDF or the use of an existing MDF), the user is next presented a menu of steps in the Tempo monitoring design methodology and asked which step he wishes to address. By selection of a given step, the program passes operation to one or more of the other program modules. In this transfer, the portion of the MDF containing material for this step is examined to determine if it has previously been loaded with any information. If the step has no material in it, the TEXT.DAT file is positioned to the frame containing beginning information for this step. This will allow the user to select appropriate data and load it into the MDF to complete the step. If the step is partially finished, the text file is positioned to the last frame that was accessed for that step (the frame that was being executed when the operator decided to stop work on the step) (Figure 3). This frame is repeated and material in the sequence of frames for the rest of the step is presented to the operator. He may continue to the end of the step or he may again stop execution of the step and leave the program or work on material for another step.

When work on a step is finished, either by the user looking at all material contained in the text file for the step or by choosing to end the step early, the program cycles back to the step menu and the user is asked where he chooses to go from there. If desired, the user may elect to have the main driver close all files and stop execution of the program. At a later time, these may be accessed again and more material added to the specific MDF (Figure 4).

Subroutine TEXT

This subroutine (or module) is used to read text material in the text file (TEXT.DAT), type it on the user's terminal, and possibly write some of it into the MDF (Figure 5). The module assumes that the text file has already been positioned to the appropriate frame. The module

end of material —————
for Step 5 marker
(material not complete
go to Frame 7 to con-
tinue loading)

\$\$\$05 7

STEP 6, MOBILITY OF POLLUTANTS IN THE VADOSE ZONE.

OBJECTIVE 1: IDENTIFY ALTERNATIVE METHODS FOR OBTAINING
BACKGROUND INFORMATION ON VADOSE ZONE PROPERTIES.

PROPERTY 1: THICKNESS

ALTERNATIVE METHODS TO BE UTILIZED:

ALTERNATIVE METHOD 1: EXAMINE AVAILABLE WATER LEVEL
MAPS.

PRINCIPLE: AVAILABLE WATER LEVEL CONTOUR MAPS OR
DEPTH TO WATER MAPS FOR THE MINE ARE EXAMINED AND
DEPTH TO WATER BENEATH THE POND ESTIMATED.

ADVANTAGES:

- A. SIMPLE.
- B. INEXPENSIVE.

DISADVANTAGES:

- A. DATA MAY NOT BE SUFFICIENTLY SITE-SPECIFIC,
I.E., INACCURATE.
- B. IF MAPS ARE NOT RECENT, DATA WILL NOT REFLECT
RISE IN WATER TABLE BECAUSE OF RECHARGE FROM POND.

LABOR REQUIREMENTS:

- A. EXAMINE WATER LEVEL MAPS
 - 1. SUPERVISOR 4 HRS.

LABOR COSTS:

- A. EXAMINE MAPS
 - 1. SUPERVISOR \$40

CAPITAL/OPERATING COSTS:

NONE

ALTERNATIVE METHODS CURRENTLY UTILIZED:

- - - "NONE" - - -

COMMENTS:

- - - "NONE" - - -

Material stored in
Step 6 area

Figure 4. Partially loaded monitoring design file.

PROPERTY 2: TEXTURE

ALTERNATIVE METHODS TO BE UTILIZED:

ALTERNATIVE METHOD 2: EXAMINE DRILLERS LOGS.

PRINCIPLE: LOGS OBTAINED BY DRILLERS DURING CONSTRUCTION AT NEARBY WELLS ARE EXAMINED FOR LOCATION OF STRATA IN VADOSE ZONE, AND ASSOCIATED TEXTURAL DESCRIPTION.

ADVANTAGES:

- A. SIMPLE.
- B. INEXPENSIVE.

DISADVANTAGES:

- A. GENERALLY DRILLERS ARE CONCERNED PRIMARILY WITH DEPOSITS BENEATH THE WATER TABLE. DESCRIPTION OF VADOSE ZONE SEDIMENTS MAY BE SKETCHY.
- B. RESULTS MAY NOT BE TRANSFERABLE TO THE POND SITE.

LABOR REQUIREMENTS:

- A. EXAMINE DRILLERS LOGS
 - 1. SUPERVISOR 4 HRS.

LABOR COSTS:

- A. EXAMINE LOGS
 - 1. SUPERVISOR \$40

CAPITAL/OPERATING COSTS:

NONE

ALTERNATIVE METHODS CURRENTLY UTILIZED:

- - - "NONE" - - -

COMMENTS:

- - - "NONE" - - -

end of Step 6 material —→ :06 10
marker (step finished) —→ \$07 11
end of Step 7 material
marker (step not finished)

Figure 4. (continued)

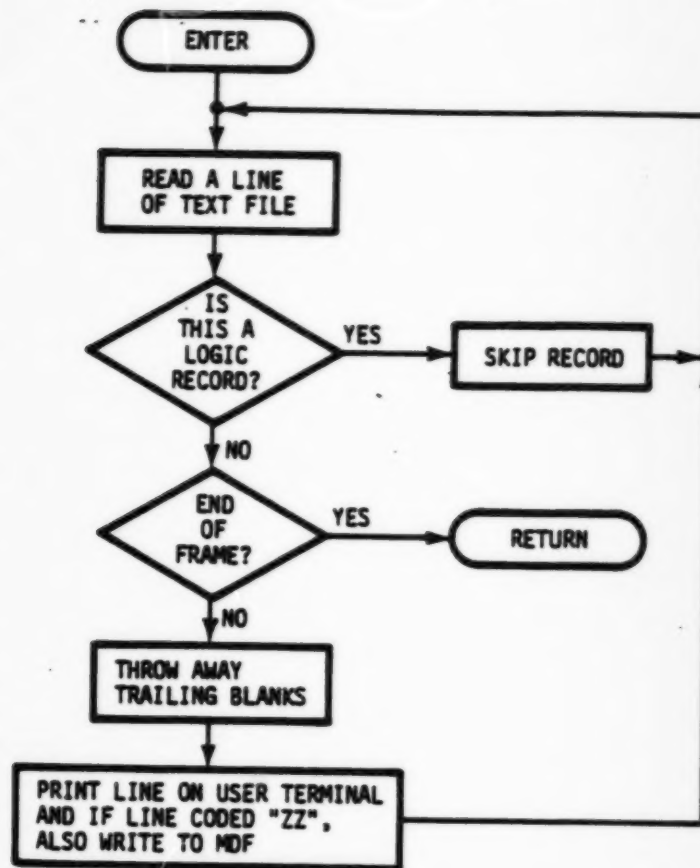


Figure 5. Flowchart of subroutine TEXT.

operates by first reading a line from the text file. It then checks to see if there are any logic or end-of-frame symbols at the first of the line. Given these are not found, the line of information is stripped of all trailing blanks or spaces and the first two characters of the line are removed. The resultant line is typed on the user's terminal and if it was coded with a ZZ as the first two symbols, it is also written to the user's MDF.

After typing the line on the user's terminal, another line is read from the text file and processed as above, etc. In the event a logic code symbol (##) is found at the first of a line, the line is ignored and the next line read from the text file. The occurrence of frame number (@@) causes the routine to transfer control to the calling program.

Subroutine TALK (IFRM)

This subroutine is entered to position the text file to a specific frame number (IFRM) (Figure 6). This is achieved by comparing the current frame number (INDEX) against the required frame number (IFRM).

The routine begins by checking if it is already there. If it is not, the direction of movement from the current location is determined and the text file read in that direction. To speed up this search, only the first two characters of each line are read. An index is used to count the number of frames read (@@ symbols passed) so as to arrive at the required frame. When the sought frame is found, it is positioned at the top of the frame and the TALK module called. TALK then presents the material contained in the frame to the user and copies appropriately coded material to the MDF.

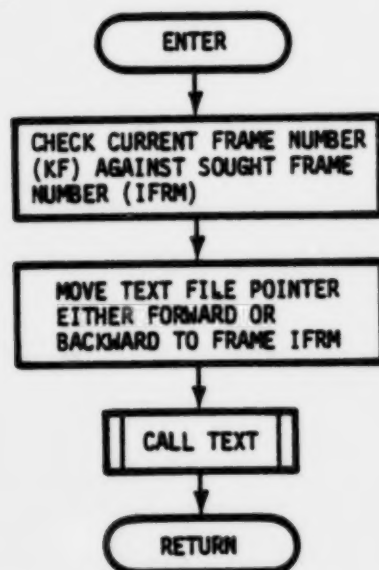


Figure 6. Flowchart of subroutine TALK.

Subroutine REEDX (NBIT)

This subroutine is used to analyze input from the user (Figure 7). It determines if there are any obvious problems with the form of the input or if the user has input selected control words that require special actions. When making a call to the subroutine, a value of NBIT greater than 0 implies that a numeric response is expected.

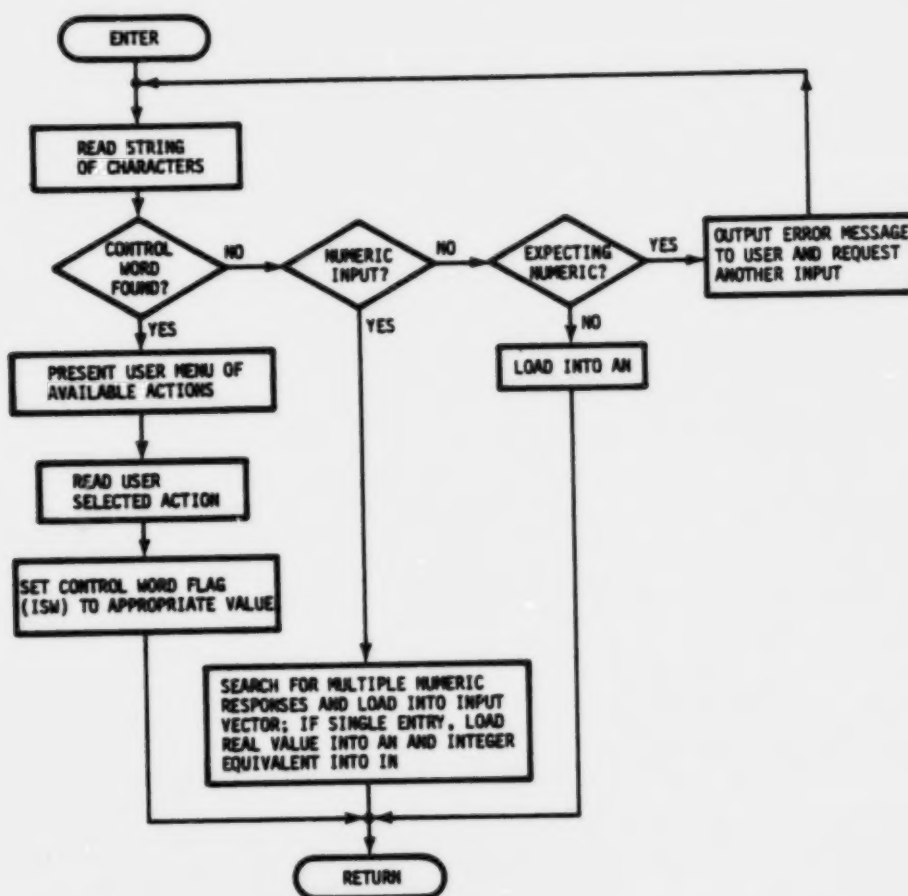


Figure 7. Flowchart of subroutine REEDX.

The subroutine processes the response on a character-by-character basis. For a numeric response, both an integer and real value are established. In the case where the value 12 was input, a value of 12 is assigned the integer variable (IN), while a value of 12.0 is given to the real variable (AN). In the event there are several numbers input, separated by spaces, they are loaded into the vector INN. The first ten elements of the vector contain these numbers, while the eleventh element contains the count of numbers in the input string. For all responses, the vector INPUT contains the characters that were input by the user.

In case a user inputs alpha to an expected alpha response, the subroutine checks the input for a special control word; if not found, it passes the input response into the calling program through the variable name, AN.

In the event the subroutine expects a numeric response (NBIT greater than 0) and it receives one or more alpha characters in the response, it first checks to see if one of the control words is present. If it is not, the user is informed that a numeric answer is required and is requested to reenter with an appropriate numeric response.

If it is not, the user is informed that a numeric answer is required and is requested to reenter with an appropriate numeric response.

If a control word is found, additional information is requested from the user. The current control words are STOP, ANALYSIS, and EXIT. In the event one of these words is input, the program presents a menu of possible actions. The following are the actions and their numeric codes:

1. Stop execution of the current step and return to the directory of available steps in the monitoring methodology
2. Stop execution of the program
3. Perform data analysis before continuing
4. Insert comments into the MDF.

The user is asked to make a numeric response. Based on the user's response, a value is assigned to the parameter ISW to indicate the action requested. This value is passed through the labeled common VALS to the calling program. Control is then passed to the calling program.

Subroutine EXTND (IX, IBIT, IFRM)

This subroutine is used to insert material into the MDF (Figure 8). Upon initiation, the new MDF is built by writing a series of records containing successive step numbers. These are the specific frame numbers to go to the text file to begin examination of material for possible use in each step. As material is selected for a given step from the TEXT.DAT file, it is loaded into the MDF30.DAT file. The material is followed by a record containing that particular step number. Material may be loaded into the MDF by addressing the steps in any order. As an example, this allows material to be inserted into Step 4 and then additional material added into Step 3.

The arguments in the subroutine are the step number (IX), whether to get ready to add material (IBIT=0) or cover the added material up with the rest of the steps in the file (IBIT=1), and the frame number to branch to in order to finish the step (IFRM).

The subroutine uses a temporary file for manipulating text. It is named MDF30.TEM on the open statement in the main driver. Similar to the other files, it may be called anything as long as the selected name appears in that statement.

An example of adding material might clarify use of the subroutine. For the adding of material to Step 4, the MDF is read to the point where information ends for Step 4 (there may already be some information loaded into that step). While this reading is being conducted, a counter keeps track of the number of records to the end of information for Step 4. The rest of the information in the MDF is copied to the MDF30.TEM file. Both the MDF30.DAT and MDF30.TEM files are rewound. The MDF30.DAT file is then skipped to the known number of records to the end of information in Step 4. The new information for that step is written to the MDF30.DAT file. When finished, the old information on the MDF30.TEM file is copied line by line to the MDF30.DAT file so that it follows the recently added Step 4 material. This results in the development of a new MDF30.DAT file containing the new added information for Step 4.

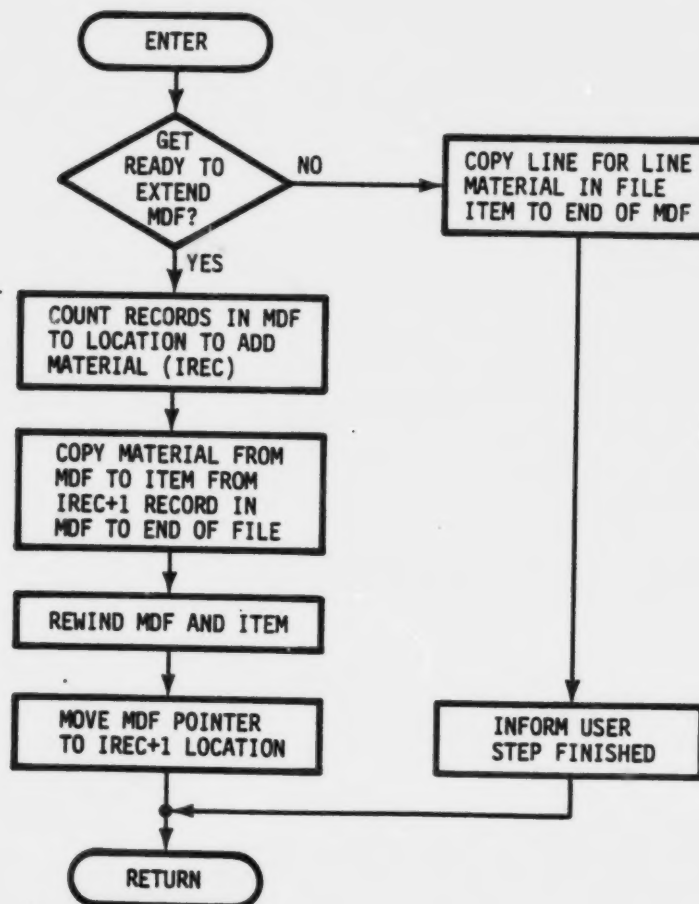


Figure 8. Flowchart of subroutine EXTND.

In operation, the module is entered twice to add material to a step. The first entry is to position the file to receive the information and the information added. The module is then exited and reentered to cover that material with material from higher numbered steps already contained in the MDF. Finally, the files are rewound.

At the end of insertion of material for a given step, the status of NBIT is checked to determine if the end of possible information for the step has been reached or if operation of the step has been stopped early. If the step is stopped early, the last record of the step might be coded \$\$004 103. (Figure 12, and Section 4). This indicates it is the end of information contained in the MDF for Step 4, while it is not the end of all available information for that step (the \$\$ code). The remaining information for the step is obtained by going to frame 103 in the main text file, TEXT.DAT. This is the frame the user was addressing when he stopped execution of the step. If the step was finished by having examined all information in the TEXT.DAT file for that step, it would be coded !!04.

In the event the step already contains all information available for that step, the notice ***** STEP 4 ALREADY FINISHED ***** is given the user and control is passed to the calling program.

Subroutine COPIX (IX)

This subroutine (Figure 9) is used to copy appropriately coded text material from the main text file (TEXT.DAT) to the MDF file. Each line of information in the text file has a two-symbol code at the first of the line. This subroutine examines these first two symbols of each line of text in the current text frame and, if the two symbols are coded equal to IX, it is copied to the MDF.

The routine begins by positioning the text file at the top of the current frame. A line of text is read and the first two characters compared to the file MDF30.DAT. If the first two characters are not equal to IX then the next line of text is read and the first two characters compared to IX. This continues for each line of text in the current frame. When the first two symbols encountered are those that signify the end of the frame (Figure 14), the subroutine transfers control back to the calling program.

This subroutine is primarily used to transfer a portion of the text file associated with a particular alternative method of monitoring to the user's MDF. It is generally a section of text associated with a user's numeric response of IX.

Subroutine SOURCE

This subroutine (Figure 10) addresses the possible sources of pollution present or associated with the mine. The module is entered by the user's selection of Step 2 in the step menu.

This routine presents each of the possible pollution sources present and their associated reference number. The user is then asked whether each

one is present. In the event that the user states the source is present, the number and source name are written to the MDF. This continues for all the sources stored in the subroutine. When the full list has been covered, a step-completed record (!!) is written into the MDF and control returned to the calling program.

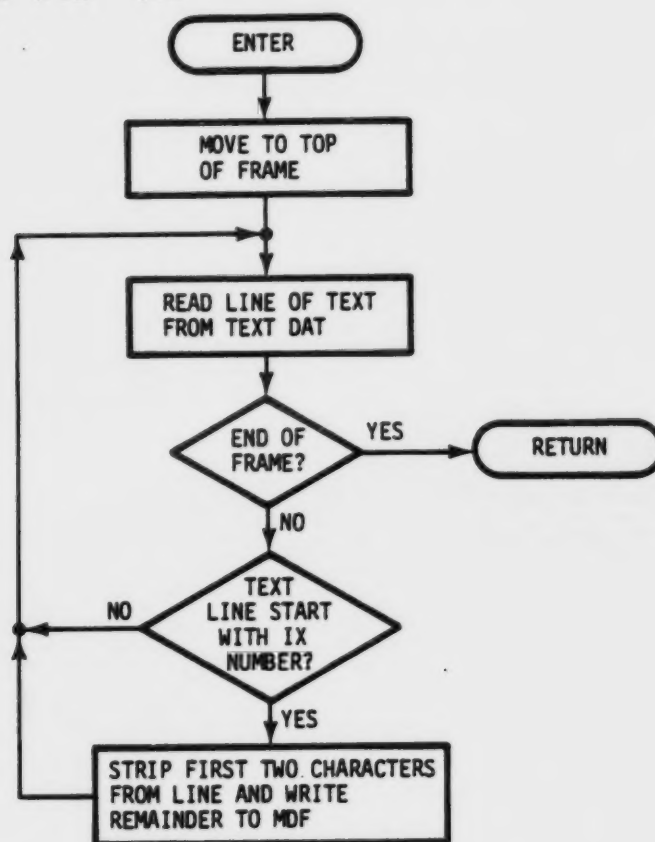


Figure 9. Flowchart of subroutine COPIX.

Subroutine BRANCH (IFRM)

This subroutine (Figure 11a and b) is used to search the frames in the text file and position the file at the beginning of the sought frame number (IFRM). It also reads the frame logic and compares the user response against that logic to determine which frame number to branch to for the rest of a given step. In addition, it presents the text material to the user for each frame in each step. Subsequently, based on the user's response to questions associated with that material, this routine copies appropriate portions of the text to the MDF, MDF30.DAT. Furthermore, this routine checks the flag that might have been set in REEDX by the user's input of a control word, overriding normal execution of frames in a step. If a control word was input, the routine determines what is to be done to honor that request. If the control

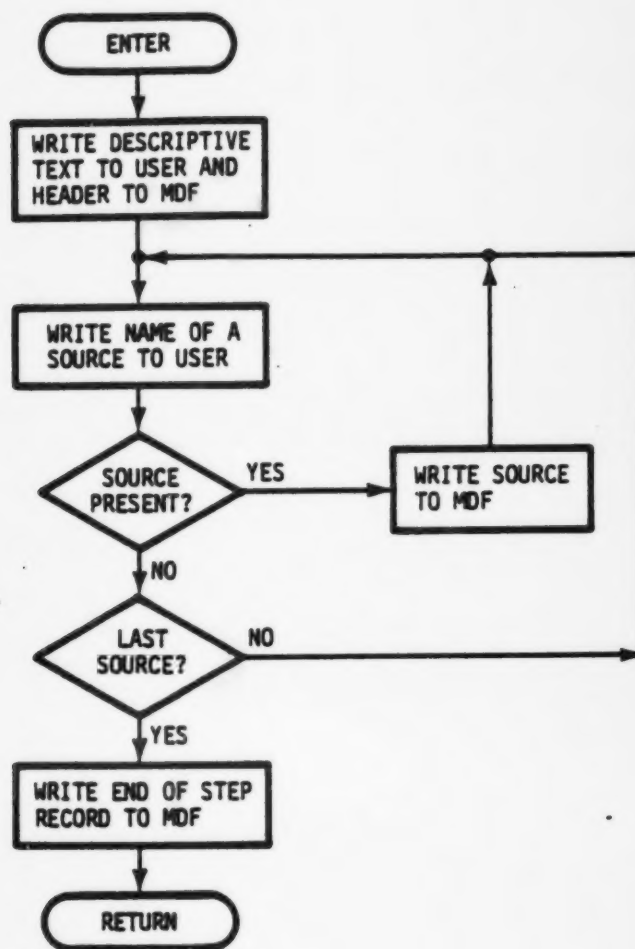


Figure 10. Flowchart of subroutine SOURCE.

word requires a premature ending of a step, the message ***** EXECUTION OF STEP STOPPED AT THIS POINT ***** is written to the MDF. This flags the break of step execution in the MDF so that it is noticed when additional material is later added into that step.

The routine begins by first calling TEXT to present text contained in the current frame on the user's terminal. On return from TEXT the logic associated with the frame is read. This is coded by one of the following two symbol pairs: 10, 11, J0, K0, K1, or L0. The meaning for these codes is given in Figure 12.

In the event an I0 or I1 is detected in the frame logic record, the routine responds by asking the user to enter the number(s) of alternative methods currently not utilized that he wants entered into his MDF. He is to enter a 0 for none. The message ***** ALTERNATIVE METHODS TO BE UTILIZED ***** is written to the MDF. The routine then

reads the user response and interprets it for key words, etc. The appropriate section of text associated with the input alternative method number(s) is written to the MDF through the use of COPIX. If 0 is entered by the user, the word ***** NONE ***** is written to the MDF.

The subroutine then asks the user to input the number(s) of alternative methods that are currently employed. Again, a 0 is used to signify none. The message ***** ALTERNATIVE METHODS CURRENTLY UTILIZED ***** is written to the MDF and the input from the user is interpreted and appropriate text copied to the MDF through the use of COPIX, or, if 0 was input, the word ***** NONE ***** is written to the MDF. The subroutine then queries whether the user wishes to enter any comments into the MDF. This allows him to enter anything that might better explain why he selected the above alternative methods or any other message that might be useful to have in the MDF at this time. In the event the user wishes to insert information into the MDF, he types YES and then types as much text as he wishes to insert, with the word LAST typed on the final line at the end of the message. The message is copied line by line to the MDF. The routine then moves the TEXT.DAT file to the frame number that was listed after the I0 or I1 code.

If the program detects a J0 on the frame logic record, the text file is moved to the frame number that appeared following the J0. There is no input requested from the user.

The occurrence of the code K0 signifies that a question will be asked in the frame requiring a response from the user. His numeric response is used to determine any material that will be copied to the MDF. The COPIX routine handles this transfer of information to the MDF. The BRANCH routine then branches to the frame number listed on the K0 logic record.

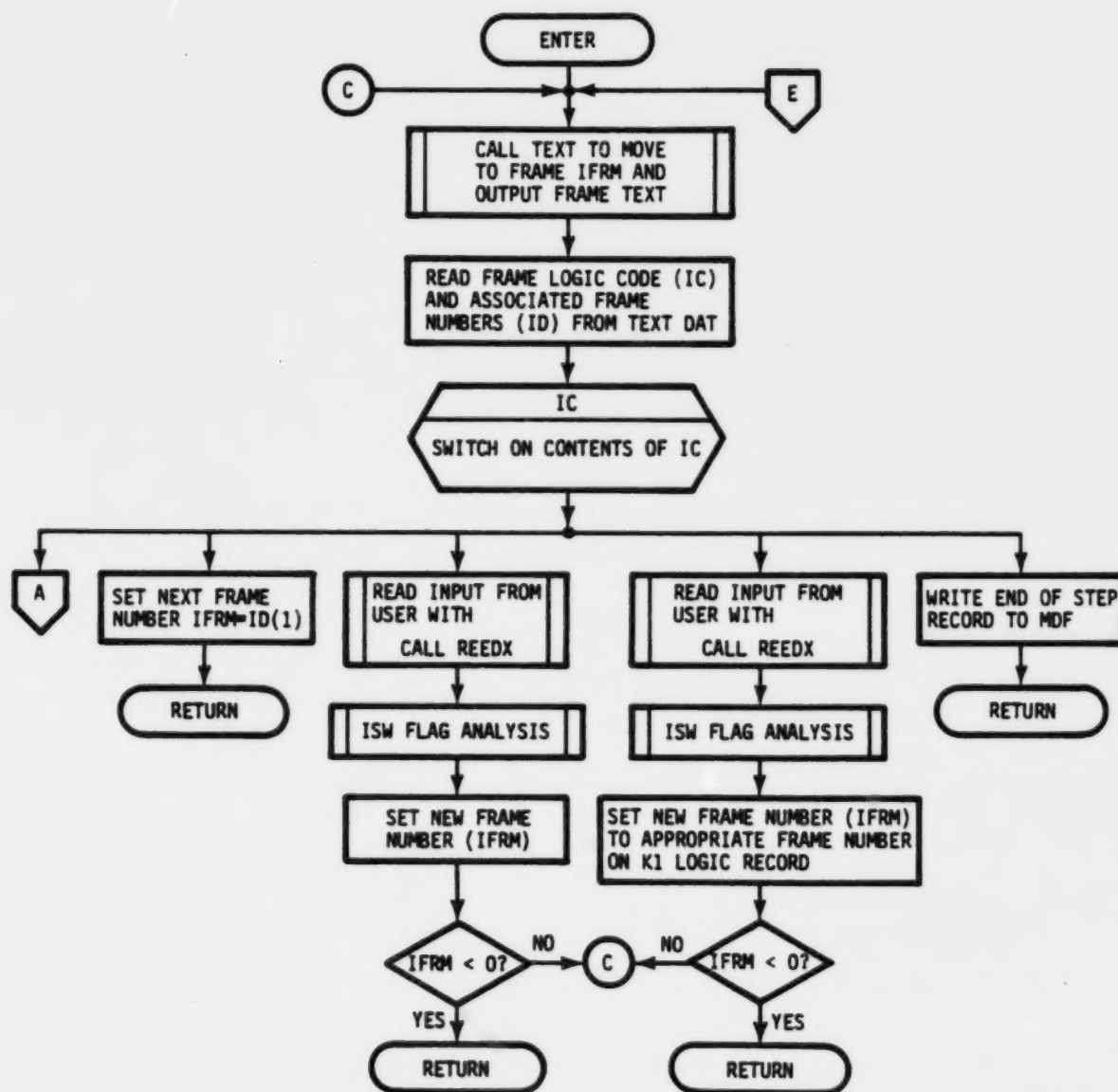


Figure 11a. Flowchart of subroutine BRANCH.

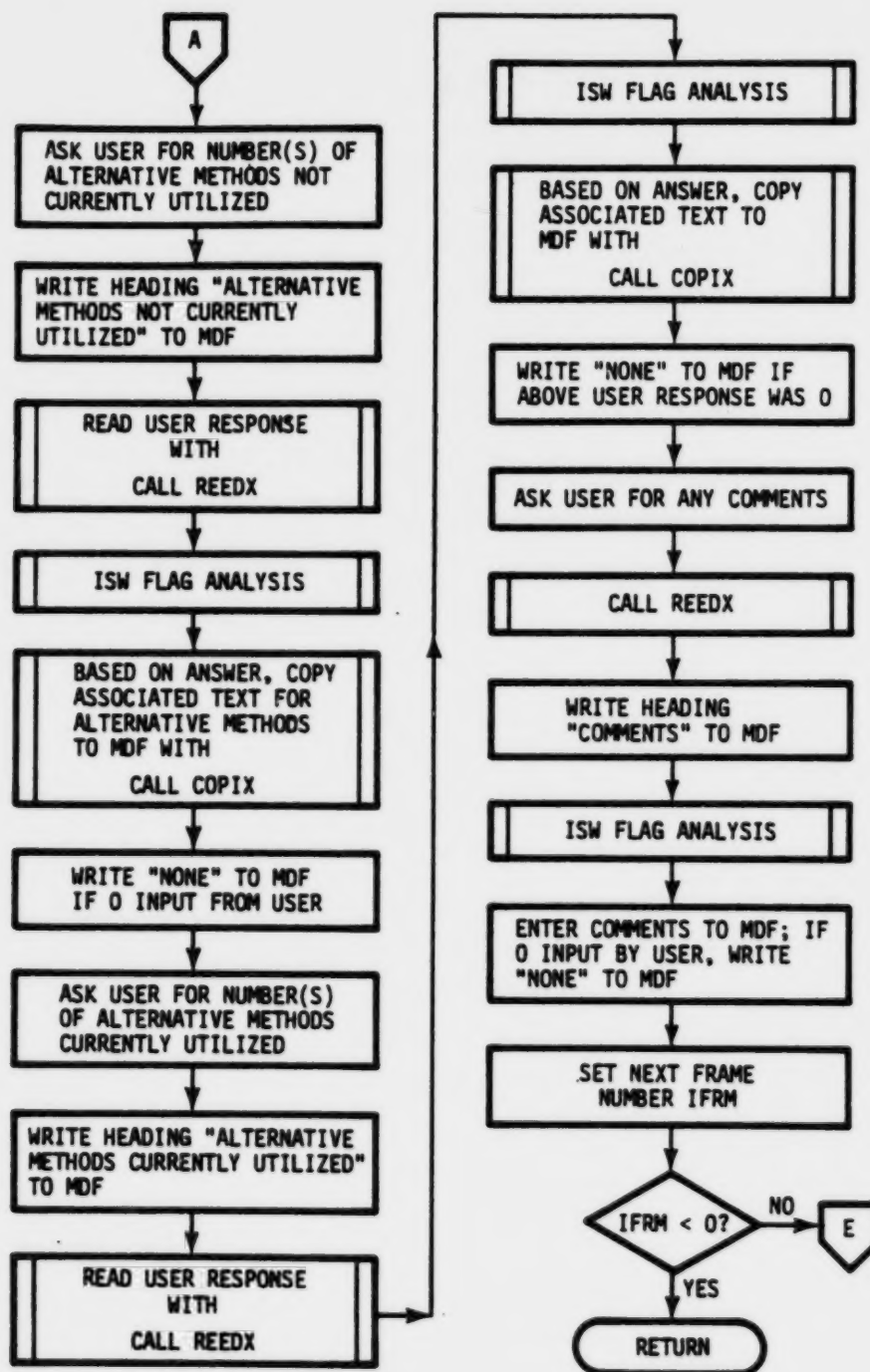


Figure 11a. (continued)

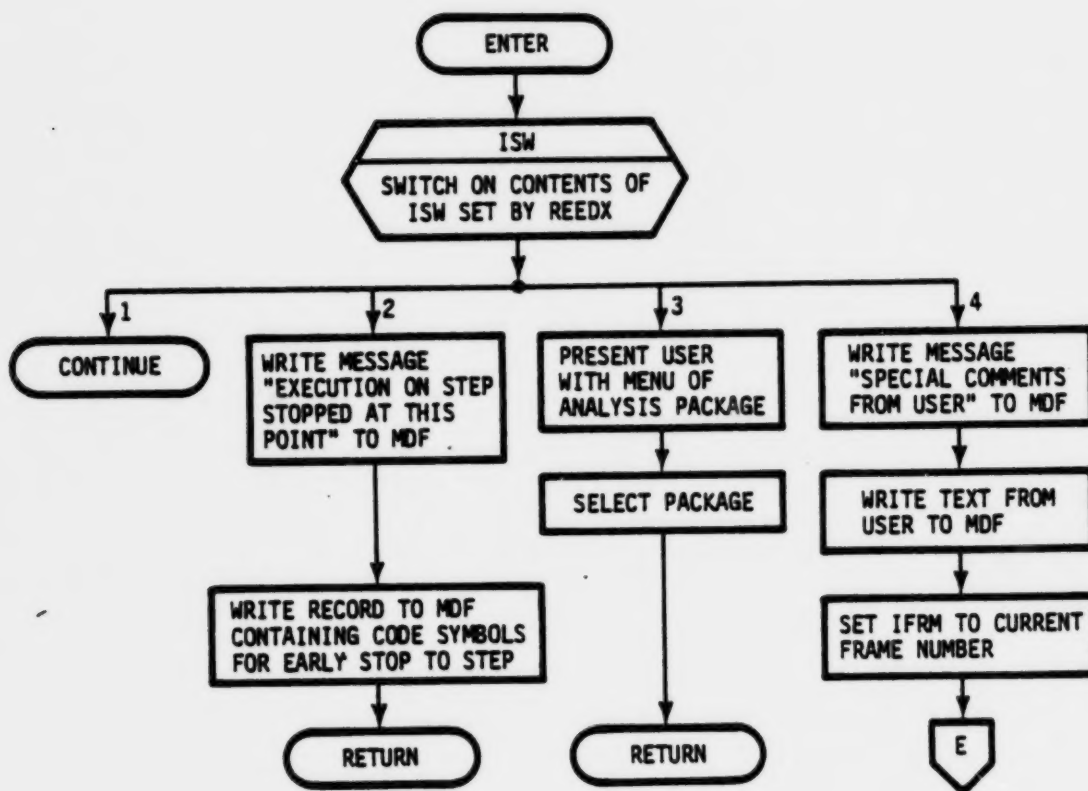


Figure 11b. ISW flag analysis imbedded in BRANCH.

IO	ONLY ONE FRAME NUMBER TO BRANCH TO FOR ANY RESPONSE. THERE ARE SEVERAL QUESTIONS ASKED THE USER: WHAT ALTERNATIVE METHODS CURRENTLY NOT UTILIZED THAT HE WISHES TO ENTER INTO HIS MDF: WHAT ALTERNATIVE METHODS ARE CURRENTLY UTILIZED: WHAT COMMENTS HE WISHES TO ENTER INTO HIS MDF.
I1	SEVERAL FRAME NUMBERS ARE AVAILABLE TO BRANCH TO DEPENDING ON THE RESPONSE TO WHAT ALTERNATIVE METHOD IS TO BE UTILIZED AND ENTERED INTO THE MDF: AS IN IO THERE ARE SEVERAL QUESTIONS ASKED THE USER. HIS FIRST RESPONSE TO WHAT ALTERNATIVE METHOD IS TO BE UTILIZED IN THE FUTURE AND ENTERED INTO HIS MDF IS ONE LESS THAN THE SEQUENTIAL LOCATION OF THE FRAME NUMBER TO BRANCH TO IN THE LIST OF FRAMES PROVIDED ON THE I1 LOGIC CODE LINE IN THE FRAME.
JO	THIS CODE IS FOR A DIRECT BRANCH TO THE FRAME NUMBER FOLLOWING IT WITH NO INPUT FROM THE USER AFTER THE MATERIAL IN THE FRAME HAS BEEN PRESENTED TO HIM.
KO	THIS CODE IMPLIES THAT THERE ARE SEVERAL FRAME NUMBERS LISTED WITH THE CODE. THE NUMERIC RESPONSE OF THE USER IS ONE LESS THAN THE POSITION NUMBER OF THE FRAME TO BRANCH TO IN THE LIST OF THE FRAME NUMBERS.
LO	THIS CODE IMPLIES THIS IS THE LAST FRAME IN A PARTICULAR STEP AND IS THE CODE TO BRANCH TO THE FRAME WHERE THE MENU OF AVAILABLE STEPS IS PRESENTED THE USER TO DECIDE WHERE TO GO OR WHAT TO DO.

Figure 12. Frame logic record codes and definitions.

In case a K1 is found on the current frame's logic record, there is again a question asked of the user. The numeric response of the user determines the material that will be copied from the text file to the MDF. The numeric response of the user also determines which of the several frame numbers listed after the K1 code on the logic record will be used. The frame number to be branched to has a position number one greater than the number input by the user. As an example, an input of 1 from the user would imply that the second frame number in the list of frame numbers on the K1 logic record would be used.

The code L0 implies that the current frame is the last in the sequence of frames used to address a specific step. When this code is detected, the program returns control to the calling program to allow the menu of available steps in the methodology to be presented to the user.

Most user inputs are checked to determine if there is a control word entered or if the response is not of the expected form. If the user decides to stop execution of the current step, he can inform the routine by typing STOP -- in which case the routine writes the message ***** EXECUTION OF STEP STOPPED AT THIS POINT ***** to the MDF. The record containing the code for the early termination of the step (\$\$) is also written to the MDF, along with the current frame number. The program then returns to the calling program to present a menu of available actions presented to the user.

In the event the user requests an analysis to be conducted (by inputting the ANALYSIS control word), the routine branches to a point where a menu of available analysis routines are presented. At the current time, these routines are not active.

Another control word action that might be requested by the user is the writing of comments into the MDF. This is achieved by writing the message ***** SPECIAL COMMENTS FROM USER ***** into the MDF. The message from the user is then input to the MDF line by line with the word LAST typed on the last line of the message to signify the end of the message. Following this, the routine branches back to the text file and the current frame is presented to the user again.

Subroutine RDMDF

This subroutine (Figure 13) is used to read the text stored relative to each step in the MDF (MDF30.DAT). It asked the user which step's text he would like to examine in the MDF. Upon receipt of this number, the appropriate area in the MDF30.DAT file is located and the information in that area read and displayed on the user's terminal.

Information is stored in the file using several symbols to signify the end of information for a given step. A \$\$ means the step has not been finished, while a !! at the end of the text in a step means the step is finished. If the step is not finished, a \$\$ and the last frame number accessed will be given. Similarly, if one is just beginning the step, the \$\$ and the frame number in TEXT.DAT to begin examination of material for the step. These codes and the writing of the frame numbers

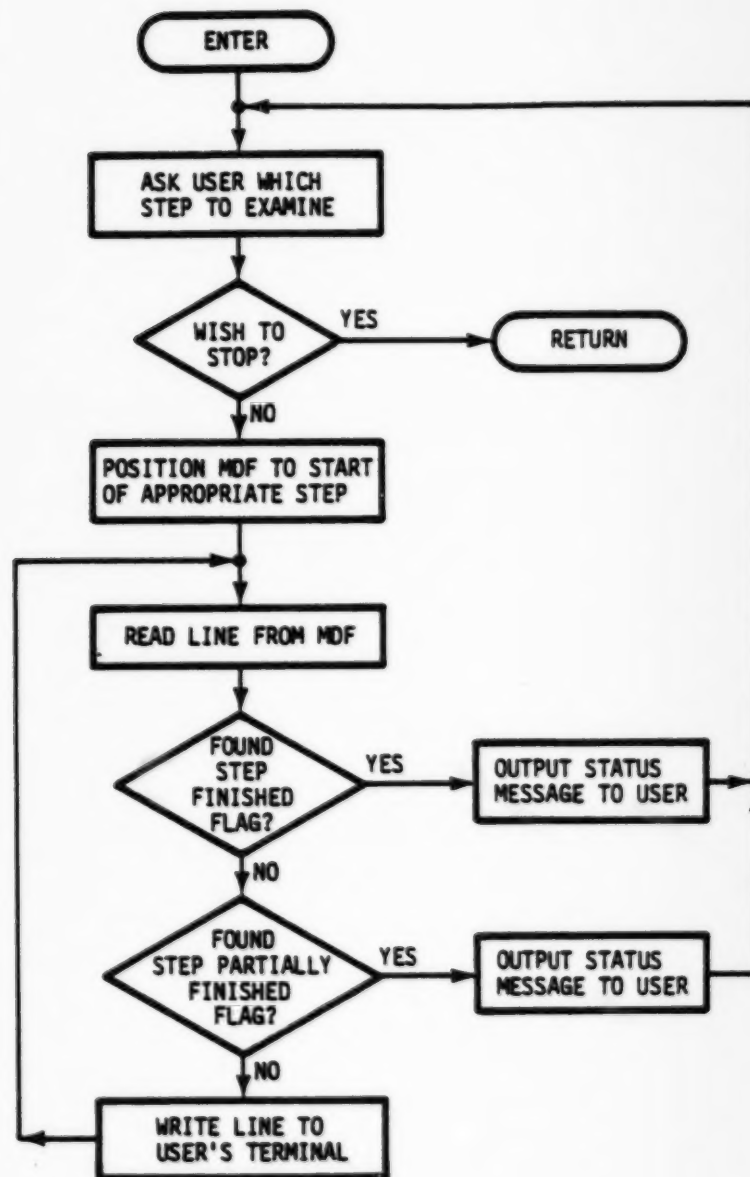


Figure 13. Flowchart of subroutine RDMDF.

are all transparent to the user and will be important only when a new TEXT.DAT file is used -- in which case the frame numbers for the start of each step will have to be set in the DATA (Appendix A, Page 45) statement at the beginning of the main driver program. The frame numbers set in that DATA statement are automatically transferred to the MDF30.DAT file.

The subroutine operates by searching to the appropriate step location, reading a line of text in the file, stripping trailing blanks or spaces from the line, and printing the line out on the user's terminal. The next line is then read from the MDF and checked for special characters. Given they do not appear, the line is also stripped of trailing blanks and printed on the terminal. When a \$\$ or !! is encountered, the program responds by presenting the message ***** STEP NOT FINISHED ***** or ***** STEP FINISHED ***** to the user. The user is then asked if he would like to examine the contents of another step or stop. If he chooses to stop, the subroutine returns control to the calling program.

SECTION 4

BUILDING THE TEXT.DAT FILE

The existing TEXT.DAT file, as well as replacement or modification of it, is assembled in several stages. First, all material that is to be presented to the user is assembled. That material is then broken into groups of several lines addressing specific items. These are called frames and are used to facilitate comprehension by the user (Figure 1). From the material in the frames, the user selects appropriate items to be entered into his tailor-made monitoring design plan. To assist in determining which items from a given frame are to be entered into the user's monitoring design file (MDF), questions are incorporated into many of the frames. Next, each frame has a logic code associated with it along with a frame number. The frame numbers are sequential integers starting with 1. The logic code is used to inform the program what input is expected from the user and how to process his response. As an example, a numeric response might be expected for a certain portion of the frame text. The associated logic code might be KO 143. This means that a numeric response is expected from the user. The program will then copy appropriate material relating to that response from the frame to the MDF. Next, the program will position the text file to frame 143 and present material found there to the user.

The text file is built from a copy of formatted text material having the frame numbers and logic code on it. This rough copy is used to build a text file on the computer through the use of an editing program available at the given computer installation. The typist needs only a rudimentary knowledge of how to operate the text editor and computer terminal. The task is roughly equivalent to typing straight manuscript copy on a typewriter.

Once this rough material has been entered into the computer and a text file built, the file is printed and checked for errors. The corrections to the main file can be inserted into the file by data entry personnel or a typist familiar with use of the text editor.

When the text material for all the frames has been corrected and is in final form, the file is printed by a line editor such that each line has a number. The next step in building the TEXT.DAT file is to assign a two symbol line code to each line of text in each frame.

The two-symbol line code is first marked on the line-numbered, printed copy of the file. A ZZ is then placed at the beginning of all lines in the file and, utilizing a line-oriented text editor, the ZZ might be replaced with 01, 02, 03, CC, or whatever is appropriate on each line or group of lines. The result is the finished TEXT.DAT file that has been stripped of its sequential line numbers by the editor (Figure 14). It is now ready for use by the main program.

Corrections may be made or additional frames added to the TEXT.DAT file by utilizing the text editor. The text material may be changed in any manner as long as each line in the frame begins with an appropriate two-symbol code. Lines may be added or deleted as required. The addition of new frames requires that they have sequential frame numbers increasing from the highest (or last) value found in the existing TEXT.DAT file. Reference will have to be made to these new frames in the frame logic code somewhere in the existing file or they will not be accessible.

As the material in the TEXT.DAT file is oriented toward a multistep methodology, the material is broken into frame sequences that address specific steps. The beginning frame number for each step is loaded into the main program so that it will be branched to when the user selects that step to be addressed. The details of this operation are detailed in the description of the main driver.

Frame 6 cont'd	03	PRINCIPLE OR PURPOSE: CONSISTS OF A STOPPED
	03	SAMPLE BOTTLE LOWERED TO THE DESIRED DEPTH ON A
	03	STRING. BY JERKING ON THE STOPPER VIA
	03	A STRING, THE BOTTLE IS OPENED AND WATER ENTERS
	03	THE BOTTLE.
	03	
	03	ADVANTAGES:
	03	
	03	A. SIMPLE, EASY TO CONSTRUCT.
	03	B. MORE SUITABLE THAN METHOD 2 IN OBTAINING
	03	SAMPLE FROM DISCRETE DEPTHS.
	03	C. INEXPENSIVE IF SAMPLING IS INFREQUENT.
	03	
	03	DISADVANTAGES:
	03	
	03	A. CANNOT BE USED FOR DETERMINING DISSOLVED
	03	GASES.
	03	B. SOME MIXING OCCURS BETWEEN WATER IN
	03	BOTTLE AND WATER IN POND AS SAMPLE IS
	03	BROUGHT TO SURFACE.
	03	C. EXPENSIVE IF LARGE NUMBERS OF SAMPLES
	03	REQUIRED.
	03	
	03	LABOR REQUIREMENTS:
	03	
	03	(SEE GENERAL DATA ABOVE)
	03	
	03	CAPITAL/OPERATING COSTS:
	03	
	03	A. MEYERS SAMPLER \$10.00
	03	
	03	(SEE GENERAL DATA ABOVE)
	03	
\$\$ = Logic record	03	\$\$10 -1
@@ = Frame number	03	@@06
(Start of Frame 7)		
ZZ = Material pre-	03	ZZ -----
sented on user	03	ZZ STEP 5: EVALUATE INFILTRATION POTENTIAL.
terminal and	03	ZZ -----
copied to MDF	03	ZZ
	03	ZZINFLOW COMPONENTS OF WATER BALANCE
	03	ZZ

(continued)

Figure 14. An example of line and frame coding and structure.

01 = Material	ZZCOMPONENT 1: STREAMFLOW
presented to	01 PRINCIPLE: A LOW DAM OR OVERFLOW STRUCTURE
user; upon a	01 BUILT ACROSS AN OPEN CHANNEL. IT HAS A
numeric res-	01 SPECIFIC SIZE AND SHAPE WITH A UNIQUE FREE-FLOW
ponse of "1"	01 HEAD-DISCHARGE RELATIONSHIP.
it is also	01
copied to MDF	01 ADVANTAGES:
	01 A. GENERALLY EASY TO CONSTRUCT.
	01 B. GOOD ACCURACY FOR MEASURING LOW FLOWS.
	01 C. RATING CURVES AND TABLES ARE AVAILABLE.
	01
	01 DISADVANTAGES:
	01 A. FREE-FLOW NAPPE IS REQUIRED TO ENSURE
	01 ACCURACY.
	01 B. SHOULD NOT BE USED WHERE EXCESSIVE
	01 SEDIMENT LOADS OCCUR IN THE STREAM.
	01
	01 LABOR REQUIREMENTS/EVENT:
	01
	01 A. INSTALLATION
	01
	01 1. SUPERVISOR 4.0 HRS
	01 2. TECHNICIAN 4.0 HRS
	01
	01 B. MEASURE STAFF GAGE
	01
	01 1. TECHNICIAN 1.0 HRS
	01
	01 C. CHANGE RECORDER CHART
	01
	01 1. TECHNICIAN 0.5 HR
	01
	01 LABOR COSTS:
	01
	01 A. INSTALLATION
	01
	01 1. SUPERVISOR \$40
	01 2. TECHNICIAN \$24
	01
	01 B. MEASURE STAFF GAGE
	01
	01 1. TECHNICIAN \$6
	01

(continued)

Figure 14. Continued

	01	C. CHANGE CHART	
	01		
	01	1. TECHNICIAN \$3	
	01	CAPITAL/OPERATING COST:	
	01		
	01	A. 1. RECTANGULAR, SHARP-CRESTED	\$400
	01	2. V-NOTCH	\$350
	01	3. BROAD-CRESTED V-NOTCH	\$500
	01	4. DROP BOX	\$50
	01		
	01	B. STAFF GAGE	\$775
	01	C. AUTOMATIC WATER STAGE RECORDER	\$2,650
	01	D. STILLING WELL	\$860
	01		
02 = Material	02	ALTERNATIVE METHOD 2: FLUMES	
presented to	02		
user; upon a	02	PRINCIPLE: A FLUME IS A MEASURING DEVICE	
numeric res-	02	THAT PERMITS FREE FLOW OF WATER THROUGH A	
ponse of "2"	02	CONTROL SECTION. CRITICAL DEPTH IS CREATED	
it is also	02	DURING FLOW. KNOWING THE HEAD IN THE CENTRAL	
copied to	02	SECTION, RATING TABLES ARE CONSTRUCTED TO	
the MDF	02	EVALUATE DISCHARGE.	
	02		
	02	ADVANTAGES:	
	02		
	02	A. BY SELECTING THROAT WIDTH, A VARIATION IN	
	02	DISCHARGE RATES CAN BE MEASURED.	
	02	B. FLOW IS NOT RESTRICTED.	
	02	C. SEDIMENT DOES NOT AFFECT RESULTS.	
	02	D. RATING TABLES ARE AVAILABLE.	
	02	E. MANY FLUMES CAN BE CONSTRUCTED IN THE	
	02	FIELD.	
	02		
	02	DISADVANTAGES:	
	02		
	02	A. ACCURACY DECREASES IN SOME FLUMES WHEN	
	02	OUTLET SECTION BECOMES SUBMERGED.	
	02	B. THEY MAY BE MORE EXPENSIVE TO CONSTRUCT	
	02	OR PURCHASE THAN WEIRS.	
	02	C. THEY REQUIRE SKILLED INDIVIDUALS TO CON-	
	02	STRUCT FLUMES ACCORDING TO SPECIFICA-	
	02	TIONS.	
	02		

(continued)

Figure 14. Continued

02	LABOR REQUIREMENTS/EVENT:	
02		
02	A. INSTALLATION	
02		
02	1. SUPERVISOR	4.0 HRS
02	2. TECHNICAN	4.0 HRS
02		
02	B. MEASURE STAFF GAGE	
02		
02	1. TECHNICIAN	1.0 HR
02		
02	C. CHANGE RECORDER CHART	
02		
02	1. TECHNICIAN	0.5 HR
02		
02	LABOR COSTS:	
02		
02	A. INSTALLATION	
02		
02	1. SUPERVISOR	\$40
02	2. TECHNICIAN	\$24
02		
02	B. MEASURE STAFF GAGE	
02		
02	1. TECHNICIAN	\$6
02		
02	C. CHANGE CHART	
02		
02	1. TECHNICIAN	\$3
02		
02	CAPITAL/OPERATING COSTS:	
02		
02	A. ALTERNATIVE TYPE	
02		
02	1. HS-FLUME (MATERIAL TO FABRICATE)	\$1,500
02	2. H-FLUME (MATERIAL TO FABRICATE)	\$1,500
02	3. H-FLUME (MATERIAL TO FABRICATE)	\$1,500
02	4. PARSHALL FLUME (24 CFS, STEEL)	
02	5. PARSHALL FLUME (24 CFS, FIBERGLASS)	
02		\$2,000
02		
02	B. STAFF GAGE	\$775
02	C. AUTOMATIC WATER STAGE RECORDER	\$2,650
02	D. STILLING WELL	\$860
02		

(continued)

Figure 14. Continued

03 = Material	03	ALTERNATIVE METHOD 3: EXISTING STRUCTURES
presented to	03	
user; upon a	03	PRINCIPLE: CURVES, TABLES, AND EQUATIONS
numeric res-	03	ARE AVAILABLE FOR CALCULATING DISCHARGE
ponse of "3"	03	THROUGH STRUCTURES SUCH AS HIGHWAY CUL-
it is also	03	VERTS. KNOWING SUCH FACTORS AS FLOW
copies to MDF	03	CONDITIONS, DEPTH OF WATER AT INLET AND
	03	OUTLET, AREA OF PIPE, SLOPE, ETC. ARE
	03	REQUIRED IN THE CALCULATION.
	03	
	03	ADVANTAGES:
	03	
	03	A. INEXPENSIVE BECAUSE THE STRUCTURE IS
	03	ALREADY IN PLACE.
	03	B. ACCURACY MAY BE WITHIN $\pm 5\%$.
	03	C. SEDIMENT WILL NOT INTERFERE WITH FLOW.
	03	
	03	DISADVANTAGES:
	03	
	03	A. IF DESIGN CRITERIA ARE NOT SATISFIED,
	03	ACCURACY MAY BE $\pm 30\%$.
	03	
	03	LABOR REQUIREMENTS/EVENT:
	03	
	03	A. INSTALLATION
	03	
	03	1. SUPERVISOR 4.0 HRS
	03	2. TECHNICIAN 4.0 HRS
	03	
	03	B. MEASURE STAFF GAGE
	03	
	03	1. TECHNICIAN 1.0 HR
	03	
	03	C. CHANGE RECORDER CHART
	03	
	03	1. TECHNICIAN 0.5 HR
	03	
	03	LABOR COSTS:
	03	
	03	A. INSTALLATION
	03	
	03	1. SUPERVISOR \$40
	03	2. TECHNICIAN \$24
	03	
	03	B. MEASURE STAFF GAGE
	03	
	03	1. TECHNICIAN \$6
	03	

(continued)

Figure 14. Continued

SECTION 5

SAMPLE OPERATION OF THE PROGRAM

A sample operation of the system is depicted in Appendix B. This example presents most major characteristics of the system. The example depicts use of the system on material relative to a mine site that has not been addressed by the system before.

The first information presented to the user is a title of the program. He is then asked if this is a new or existing mine monitoring design file (MDF). As mentioned for the example, the user responds by signifying a new mine site. The program then asks if a new MDF is to be built for this lease. Since any existing MDF for this lease will be deleted and a new one started, this double questioning is to lessen the possibility of accidentally deleting an existing MDF containing material. To designate the new mine lease, the mine lease number and name of the mine are requested and stored in the MDF (see page 124).

The user is then presented a list of available areas that might be addressed in the system. Each area, or action, is associated with a numeric code. These areas largely correspond to the steps in the Tempo monitoring design methodology. In the example, the user wishes to examine the contents of the MDF (numeric code 8). The user is asked which step in the MDF he wishes to examine for any stored material. He responds with a 2 and the system responds with the message ***** STEP NOT FINISHED *****. The user next requests to examine stored information in Step 6. The program again responds immediately with the message STEP NOT FINISHED. In both cases, if there were any stored material in the step, it would have been presented before the message was output. The user next responds with 0, signifying that he wishes to return to the menu of steps that can be addressed. The menu is presented to the user (see page 125) and he now selects Step 2 (identify potential pollution sources).

Next the user is presented a list of potential pollution sources that could be present on the lease. He is asked to respond either affirmatively or negatively to the presence of each potential pollution source. The sources associated with all affirmative responses are entered into his MDF. After the list of stored potential pollution sources has been addressed, the program cycles back and presents the menu of actions available to the user. He now wishes to examine the contents of his MDF to see what has been inserted into it from the operation of Step 2 of the menu. He signifies to the program that he wishes to examine the material stored in Step 2 of his MDF. This stored material begins with the title of the name of the step, and is followed by a list of the potential pollution sources present on the lease. At the end of the list is the message ***** STEP FINISHED ***** , signifying that all material contained in the system relative to Step 2

has been addressed and that an appropriate subset of that information entered into his MDF. The user next signifies that he would like to return to the main program, and the menu is again presented to him. This time the user responds that he would like to address Step 6.

Operation of this step begins by presenting the user with the title of the step and number to verify that is what he wishes to enter. The initial objective of the step is presented, (see page 127) followed by the first property to be examined relative to this objective. Two alternative methods are presented. For each of these methods a short discussion of the primary principle and the advantages and disadvantage of the alternative methods are output by the system. Also output for each alternative method are the labor requirements, labor costs, and capital/operating costs. After the alternative methods have been presented, the user is requested to indicate which of the alternative methods he wishes to use in the future. These methods are entered into his tailor-made MDF. For the example, the response is number 2. The user is then asked which alternative methods are currently utilized. The response is 0 for none. Next the user is asked if he wishes to insert any comments into the MDF. If so, the user enters YES. The program then asks the user to enter comments and signal the end of the comment by typing the word LAST on the last line of the comment. The message or comment that the user enters is WE MIGHT CONSIDER THAT WE NOW DO SOME OF 1 AND 2.

The next property to be addressed is that of texture. For this property two alternative methods are presented (see page 129). The user is asked which of the alternative methods that he currently does not utilize he wishes entered into his MDF. The user responds by 1 and 2. Multiple numeric responses to the same question are separated by a space. The user next responds that he currently does not utilize any of the alternative methods to examine the texture property. The user in response to the next question states he does not wish to enter any comments into the MDF. For the abbreviated main text file, TEXT.DAT, used for the example, the program finds this is the end of the information that is to be addressed for Step 6 (see page 131). The program cycles back to the menu of available steps and presents it to the user. The user now responds that he would like to examine the contents of his MDF. He further signifies that he would like to examine the stored material in Step 6. The program then presents, on the user's terminal, the material stored for this step. The title of the step is given followed by the first property examined, thickness. The term ALTERNATIVE METHODS TO BE UTILIZED is followed by the alternative method selected for this property. Following this is the heading ALTERNATIVE METHODS CURRENTLY UTILIZED. Since none were selected, the term NONE is found entered into the MDF. Next, following the heading COMMENTS, is the comment that was entered by the user.

The next item found in the MDF is the material entered that addresses property 2 of texture. Following the heading of ALTERNATIVE METHODS TO BE UTILIZED are the two alternative methods selected. Following the heading ALTERNATIVE METHODS CURRENTLY UTILIZED is the word NONE to reflect that none were signified by the user. In addition, no comments were entered for this property. As this was all the

information that was to be examined for this step, the message ***** STEP FINISHED ***** is output. The program now asks if another step in the MDF is to be addressed. For the example it is not, and the user is again presented the menu of available actions. The user, by typing the numeric response of 4, informs the program that he would like to stop execution of the program (see page 134).

At a later time the program is again accessed. This time the user signifies that he wishes to work on an existing MDF. The ID of the mine is entered, and he states he does not want to look at the stored contents in the MDF. The menu of available steps is presented and he elects to work on Step 3. The material for this step is presented to the user beginning with the title and first objective. Following this, several alternative methods are presented. The user responds that he wishes to utilize methods 1, 2, and 3 in the future. He also states that he is currently utilizing method 3. Furthermore, he wishes to make a comment to explain why he has selected method 3 for both responses.

Objective two (see page 137) is then presented along with several alternative methods. The user, upon interrogation by the system, responds that he will utilize alternative method 1 in the future, that he does not currently utilize any of the methods, and that he does not wish to input any comments. This finishes the material stored in the abbreviated text file for Step 3. The menu of available steps is then presented to the user. The user elects to look at the contents of the MDF, specifically the contents of Step 3. All material that he selected for the step is presented. Since he selected several alternative methods for addressing the first objective, they are all contained in the MDF. At the end of the listing of stored material, the message ***** STEP FINISHED ***** is presented and the operator is asked if he wishes to examine another step. The answer is no, causing the program to present the menu of available actions to the user. The user again elects to stop execution of the program by inputting a numeric response of 4 (see page 144).

The next portion of the example shows the user starting execution of the system at a later time. The program is informed that the user wishes to work on an existing MDF. The ID is entered and the menu of available steps presented. The user elects to operate on Step 7. The step begins (page 145) by presenting the title and objective that is to be addressed. The first property to be examined is that of general subsurface geology. Two alternative methods are presented. The user is then queried as to which of these he wishes to utilize in the future. The response by the user is NONE. The program was expecting a numeric response when the alpha word NONE was entered, causing the program to look at the contents of the MDF, specifically the material stored in Step 7. This is presented before, up to, and including the message ***** EXECUTION OF STEP STOPPED AT THIS POINT ***** . The step material is then continued by repeating the material for that property and then going on to the next property. At the end of the material for the second property, the message ***** STEP FINISHED ***** is found indicating all material relative to that step contained in the text file has been addressed. The user then exits the program and goes back to

the menu of available steps. He now elects to address Step 5 (see page 158). Material is presented and selections made on how to address two inflow components of the water balance. This finishes the material contained in the text file for that step, and the menu of available steps is again presented the user. He now chooses to examine the contents stored in the Step 5 area in the MDF (see page 164). This is presented to the user, finishing with the heading ***** STEP FINISHED ***** , signifying that all material contained in the main text file for that step has been addressed. The menu of steps is again presented and the user elects to stop execution of the system (see page 167). The MDF now contains information for Steps 2, 3, 4, 5, 6, and 7. This completes the example.

REFERENCES

- Everett, L.G. 1979. Groundwater Quality Monitoring of Western Coal Strip Mining: Identification and Priority Ranking of Potential Pollution Sources, EPA-600/7-024 (NTIS PS-293-657).
- Everett, L.G. 1980. Groundwater Monitoring. General Electric Company Business Growth Services, Dept. 551, Schenectady, N.Y. 12305.
- Todd, D.K., R.M. Tinlin, K.D. Schmidt, L.G. Everett. 1976. Monitoring Groundwater Quality: Monitoring Methodology, EPA-600/4-76-026.

APPENDIX A
Program details, listings, and flowcharts

MAIN DRIVER

PROGRAM NAME: MAIN DRIVER - OTTO

REQUIRED SUBROUTINES: TEXT, TALK, REEDX, EXTND, COPIX,
SOURCE, BRANCH, RDMDF

ITEMS DEFINED AND ASSOCIATED FORTRAN NAMES:

IFNM - starting frame number of each step
ITXT - TEXT.DAT channel number -30
IMDF - MDF30.DAT channel number -31
ITEM - MDF30.TEM channel number -32
IOUT - user terminal display -5
INUNT - user terminal keyboard -5
OPEN - define TEXT.DAT = text file name
OPEN - define MDF30.DAT = monitoring design file name
OPEN - define MDF30.TEM = scratch file

ITEMS OUTPUT AND ASSOCIATED FORTRAN NAMES:

messages to user terminal on IOUT

REQUIRED OUTSIDE FILES (NAME, DESCRIPTION, FORMAT):

IMDF - monitoring design file - MDF30.DAT
ITXT - text file - TEXT.DAT

OPERATIONAL FEATURES SPECIFIC TO DEC-20 COMPUTER:

OPEN and CLOSE statements


```

WRITE(I,MDF,2030) KJ
DO 10 I=5,7
  KJ=KJ+1
  WRITE(I,MDF,2050) KJ,IFNM(I)
  CONTINUE
KJ=6
WRITE(I,MDF,2030) KJ
REWIND IMF
GO TO 30

```

.10

```

C---20 FIND OUT WHICH MINE MDF TO EXAMINE
WRITE(IOUT,2060)
CALL REEDX(1)
IA=IN

```

```

C--- IF(IA.NE.0) WRITE(IMDF,38) IA
C--- WRITE OUT STORED MINE INFO
C--- IF(IA.EQ.0) CALL TEXT(1)
C--- IF(IA.EQ.0) GO TO 20

```

```

C--- WANT TO LOOK AT MDF?
WRITE(IOUT,2070)

```

```

C--- READ USER INPUT
CALL REEDX(0)

```

```

C--- PERFORM LOGIC ON USER INPUT
C--- IA=INPUT(1)
C--- IF(IA.EQ.1HN) GO TO 30

```

```

C--- LOOK AT CONTENTS OF MDF
CALL RUMDF
GO TO 30

```

```

C---30 PRESENT USER MENU OF STEPS TO ADDRESS
CALL TEXT(4)
40 WRITE(IOUT,2080)

```

```

C--- READ USER INPUT OF SELECTED STEP
CALL REEDX(1)

```

```

C--- IN IS STEP TO ADDRESS
C--- ISTEP=IN
C--- GO TO (40,50,60,110,70,80,90,100),IN

```

```

C---50 GET READY TO RECEIVE INPUT
CALL EXTND(2,0,IFRM)

```

```

C--- EXAMINE PRESENCE OF SOURCES AND INPUT TO MDF
CALL SOURCE

```

```

C--- COVER NEW MDF STEP DATA WITH REST OF MDF INFORMATION
CALL EXTND(2,1,IFRM)
GO TO 30

```

```

C---60 READY MDF TO RECEIVE DATA
CALL EXTND(3,0,IFRM)

```

```

C--- GO TO APPROPRIATE FRAME IN TEXT FILE AND START
CALL BRANCH(IFRM)

```

```

C--- CLOSE STEP AND ADD REST OF MDF INFO TO MDF FILE

```

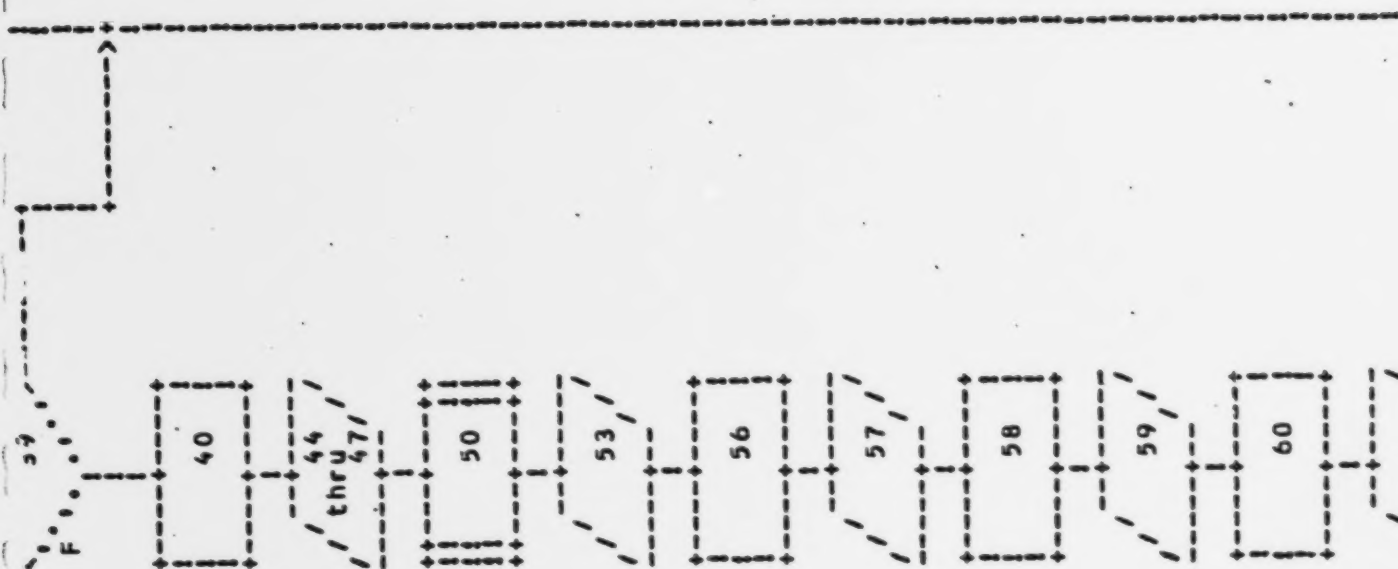
11267
11268
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11279
11280
11281
11282
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11286

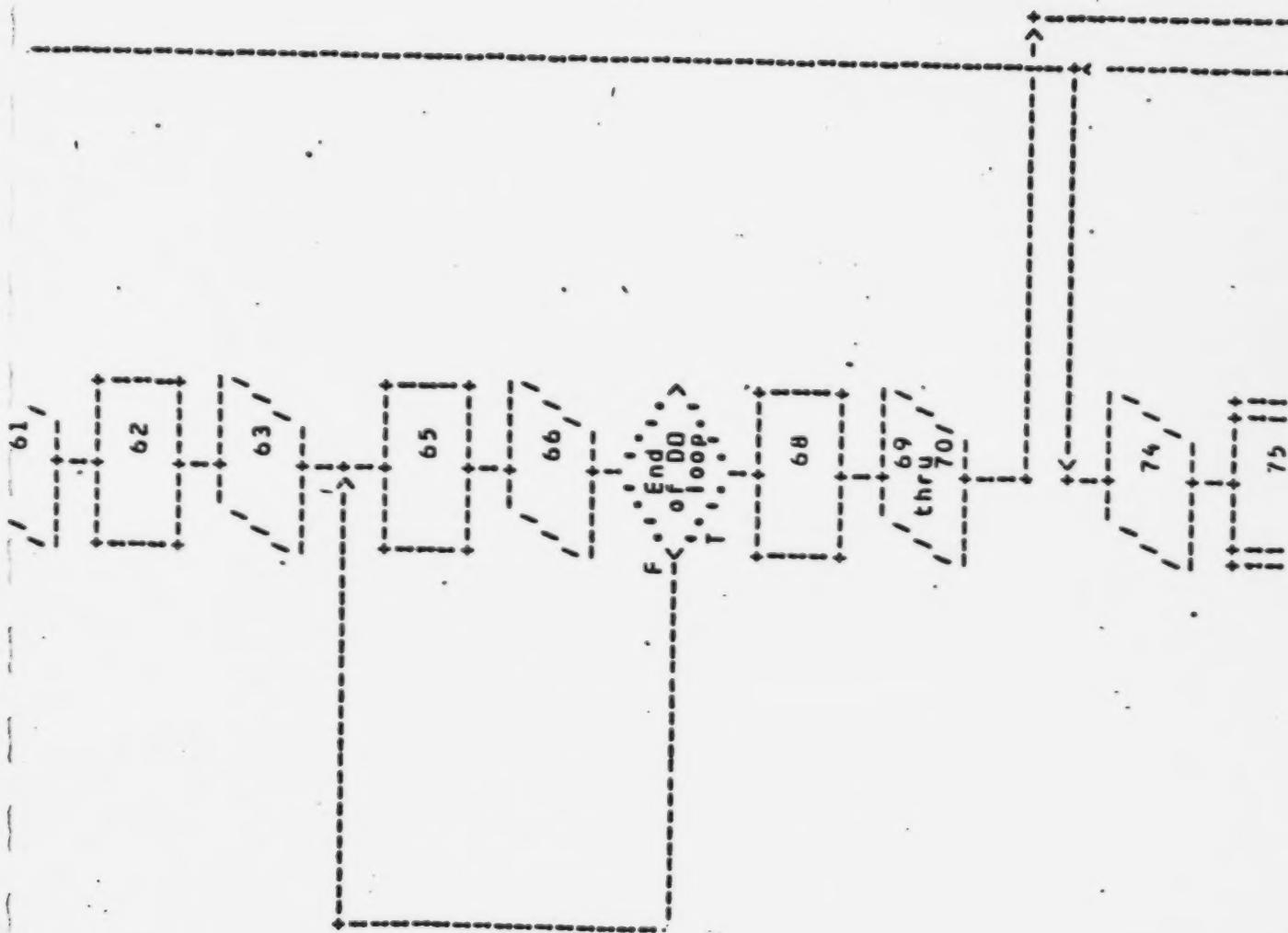
```

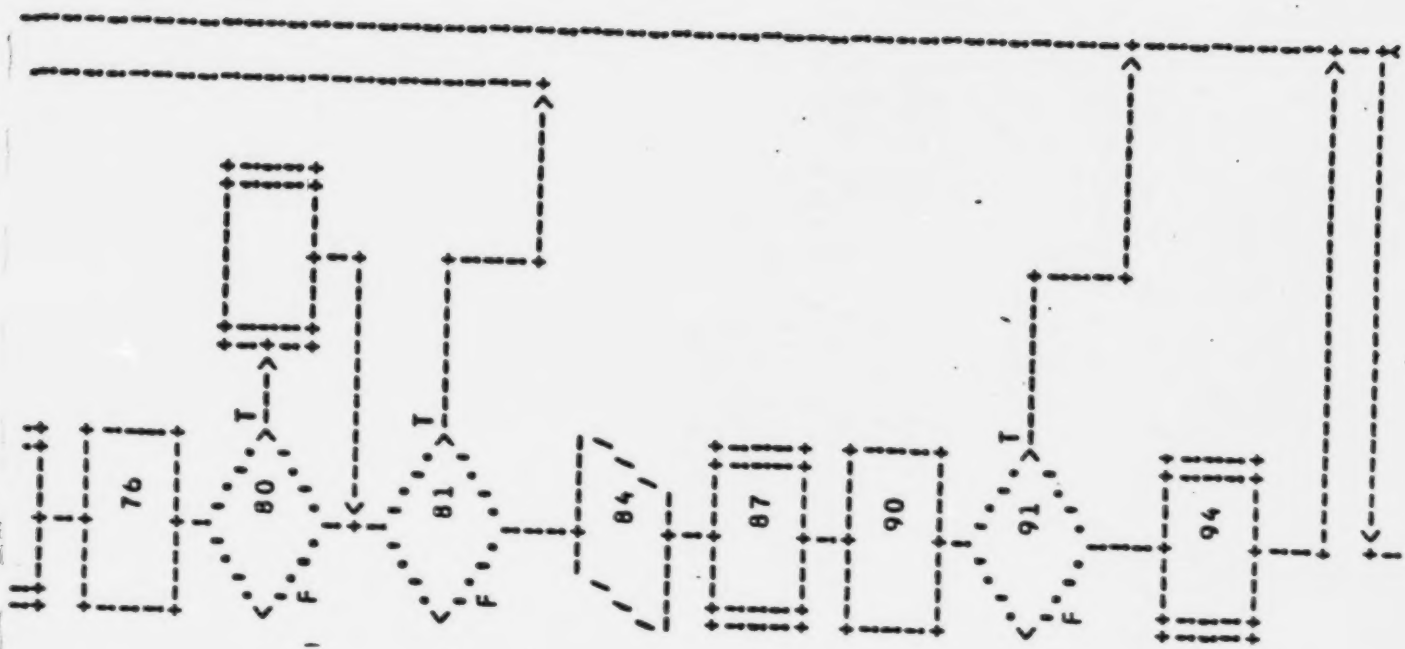
C--- 70 60 TO 30 TNL...1,...M)
C--- 70 READY MDF TO RECEIVE STEP DATA
C--- 70 CALL EXTND(5,0,IFRM)
C--- 70 GO TO APPROPRIATE FRAME
C--- 70 CALL BRANCH(IFRM)
C--- 70 CLOSE STEP AND COVER WITH HIGHER STEP DATA
C--- 70 CALL EXTND(5,1,IFRM)
C--- 70 GO TO 30
C--- 80 READY MDF TO RECEIVE DATA
C--- 80 CALL EXTND(6,0,IFRM)
C--- 80 GO TO APPROPRIATE FRAME
C--- 80 CALL BRANCH(IFRM)
C--- 80 CLOSE STEP AND COVER WITH HIGHER STEP DATA
C--- 80 CALL EXTND(6,1,IFRM)
C--- 80 GO TO 30
C--- 90 READY MDF TO RECEIVE DATA
C--- 90 CALL EXTND(7,0,IFRM)
C--- 90 GO TO APPROPRIATE FRAME
C--- 90 CALL BRANCH(IFRM)
C--- 90 CLOSE STEP AND COVER WITH HIGHER STEP DATA
C--- 90 CALL EXTND(7,1,IFRM)
C--- 90 GO TO 30
C--- 100 LOOK AT CONTENTS OF MDF
C--- 100 CALL RDMDF
C--- 100 GO TO 30
C--- 110 GET OUT OF PROGRAM
C--- 110 CONTINUE
CLOSE(UNIT-ITXT)
CLOSE(UNIT-IMDF)
CLOSE(UNIT-ITEM)
STOP
2000 FORMAT(//52H THIS IS A COMPUTERIZED SYSTEM TO SPECIFY MONITORING,
114H REQUIREMENTS /26H OF POTENTIAL GROUNDWATER,
220H POLLUTION SOURCES,
3/ /65H IS THIS AN EXISTING (E) OR NEW (N) MONITORING DESIGN
4 FILE (MDF)/31H FOR THIS LEASE (ENTER E OR N)?)
2010 FORMAT(60A1)
2020 FORMAT(51H A NEW MDF DESTROYS ALL PREVIOUS MATERIAL. IS THIS/
131H A NEW (N) OR EXISTING (E) MDF?)
2030 FORMAT(3H110,11)
2040 FORMAT(69H ENTER NEW MINE ID BY THE LEASE NUMBER(MAX. OF
1 9 CHARACTERS) FOLLOWED/60H BY A SPACE AND THE NAME OF THE
2 MINE (MAX OF 50 CHARACTERS).)
2050 FORMAT(3H$0,11,13)
2060 FORMAT(73H ENTER EXISTING 2 DIGIT MINE ID (CARRIAGE RETURN (CR)
1 GIVES STORED LIST).)
2070 FORMAT(65H DO YOU WANT TO LOOK AT THE CONTENTS OF THE DESIGN
1 FILE (YES/NO)?)
2080 FORMAT(30H WHICH DO YOU WISH TO ADDRESS?)
END

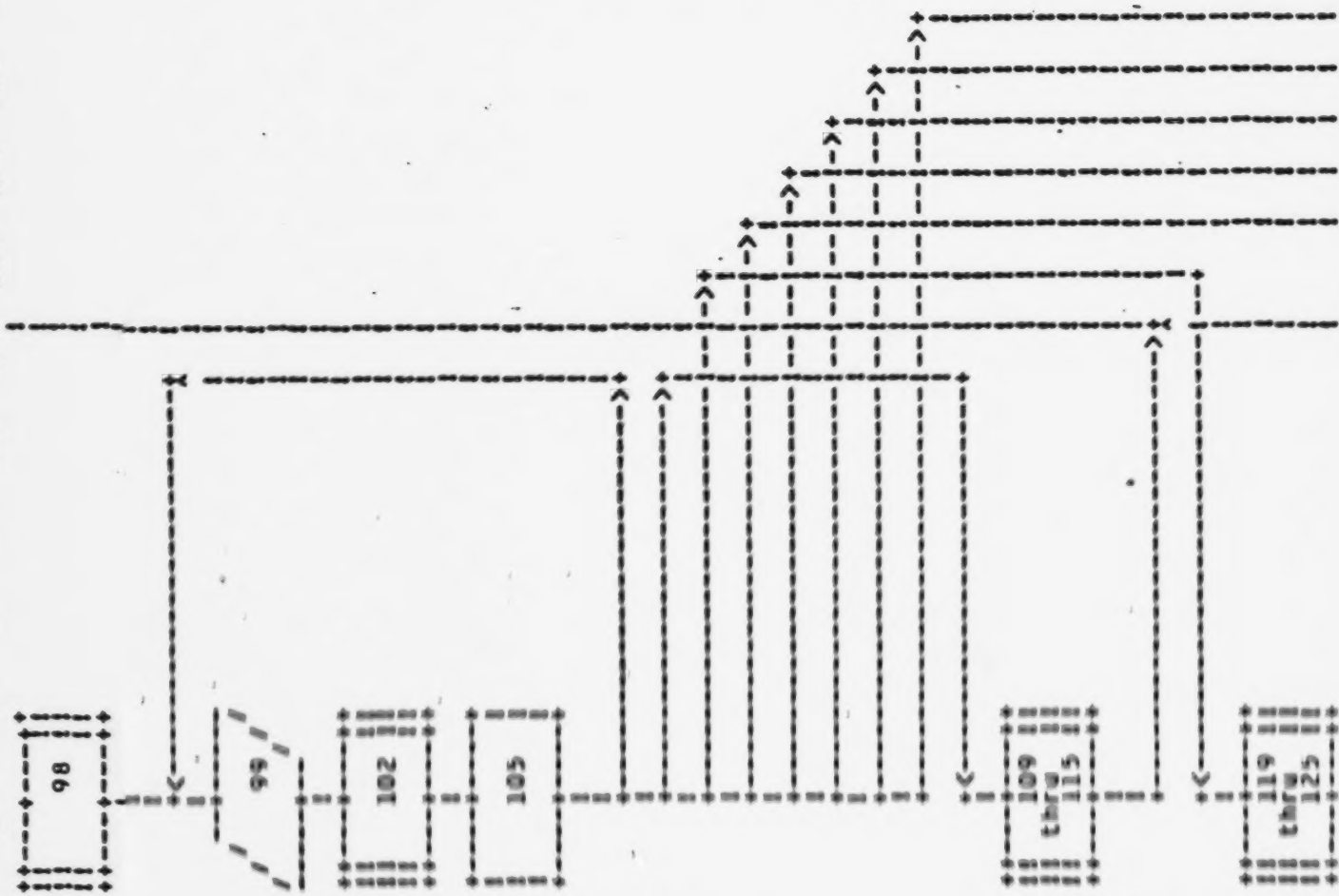
```

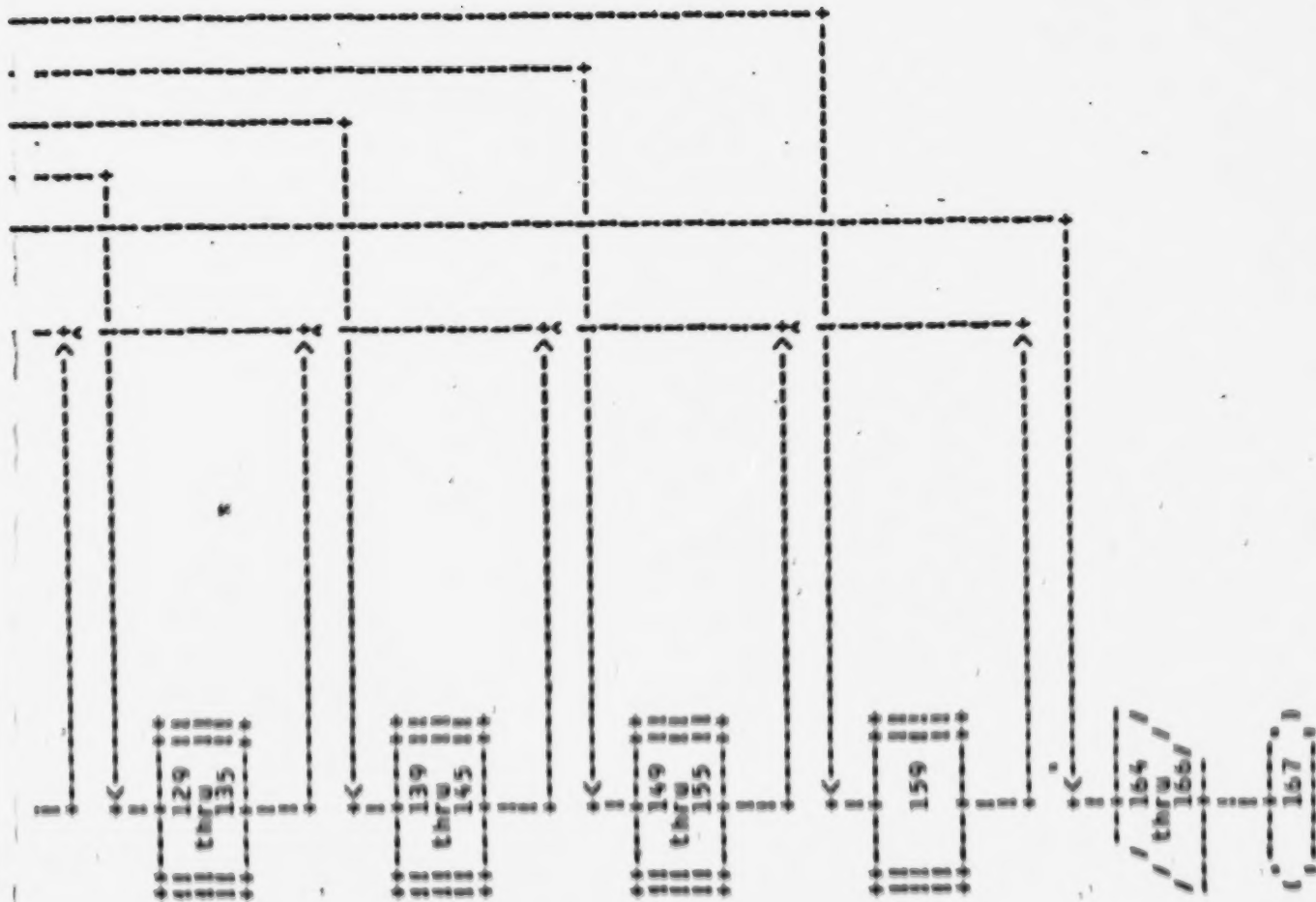












SUBROUTINE TALK

SUBROUTINE NAME: TALK

REQUIRED SUBROUTINES:

ITEMS INPUT AND ASSOCIATED FORTRAN NAMES:

read line by line from ITXT

ITEMS OUTPUT AND ASSOCIATED FORTRAN NAMES:

write line by line to user terminal - IOU and possible to MDF.30
on IMDF

REQUIRED OUTSIDE FILES (CHANNEL, DESCRIPTION, NAME):

ITXT - text file - TEXT.DAT

OPERATIONAL FEATURES SPECIFIC TO DEC-10 COMPUTER:

```

COMMON INDEX,IN,AN,INPUT(80),ITXT,IMDF,ITEM,IOUT,INN(11)
DIMENSION IAA(41)

```

```

      10 READ A LINE FROM TEXT FILE
      READ(ITXT,2000) IAA

```

```

      CHECK FOR LOGIC
      IF(IAA(1).EQ.2H##) GO TO 10
      IF(IAA(1).EQ.2HEE) GO TO 10

```

```

      IF END GET UUT
      IF(IAA(1).EQ.2H22) GO TO 40

```

```

      THROW TRAILING BLANKS OUT
      KK=41

```

```

      DO 20 L=1,39

```

```

      IF(IAA(LR).NE.2H ) GO TO 30
      KK=KK-1

```

```

      WRITE LINE TO USER TERMINAL
      WRITE(IOUT,2010) (IAA(KZ),KZ=2,KK)

```

```

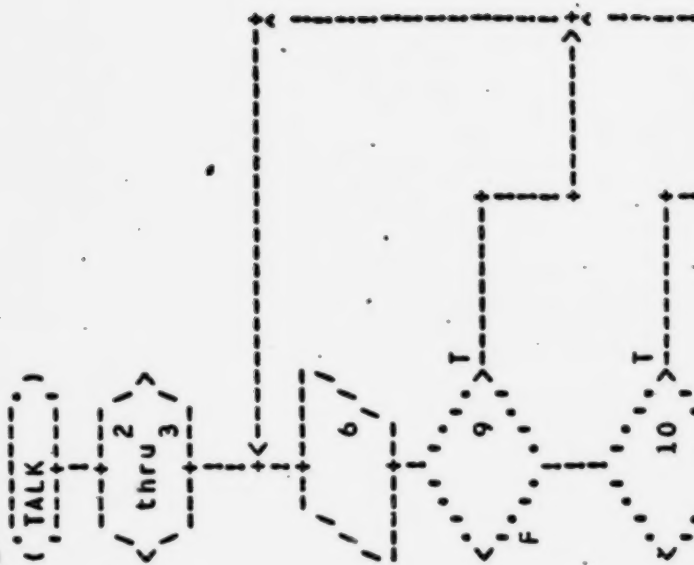
      CHECK TO SEE IF ALSO WRITE TO MDF
      IF(IAA(1).EQ.2HZZ) WRITE(IMDF,2000) (IAA(I),I=2,KK)
      GO TO 10

```

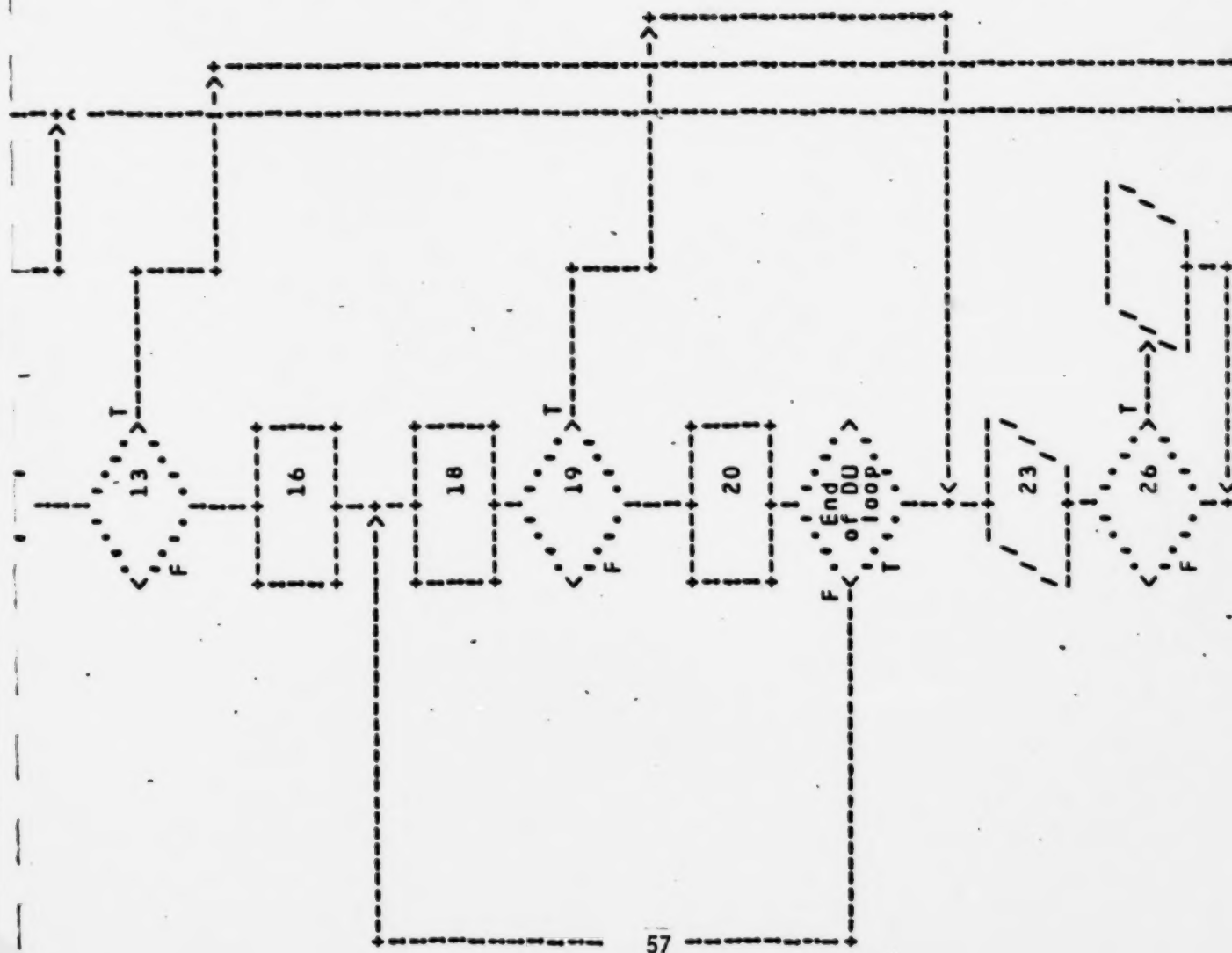
```

      40 RETURN
      2000 FORMAT(41A2)
      2010 FORMAT(1X,40A2)
      END

```



1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33





SUBROUTINE TEXT

SUBROUTINE NAME: TEXT (IFRM)

REQUIRED SUBROUTINES: TALK

ITEMS INPUT AND ASSOCIATED FORTRAN NAMES:

IFRM - sought frame number
INDEX - convert frame number

ITEMS OUTPUT AND ASSOCIATED FORTRAN NAMES:

REQUIRED OUTSIDE FILES (NAME, DESCRIPTION, FORMAT):

ITXT - text file - TEXT.DAT

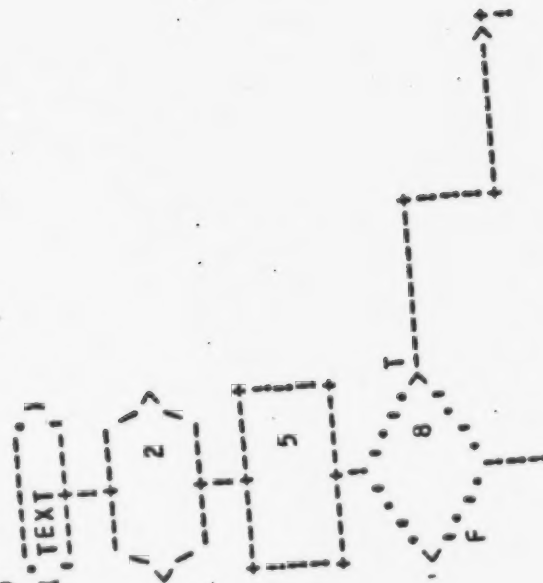
OPERATIONAL FEATURES SPECIFIC TO DEC-10 COMPUTER:

IF, AN, INPUT(80), ITXT, IMDF, ITEM, IUUF, INN(11)

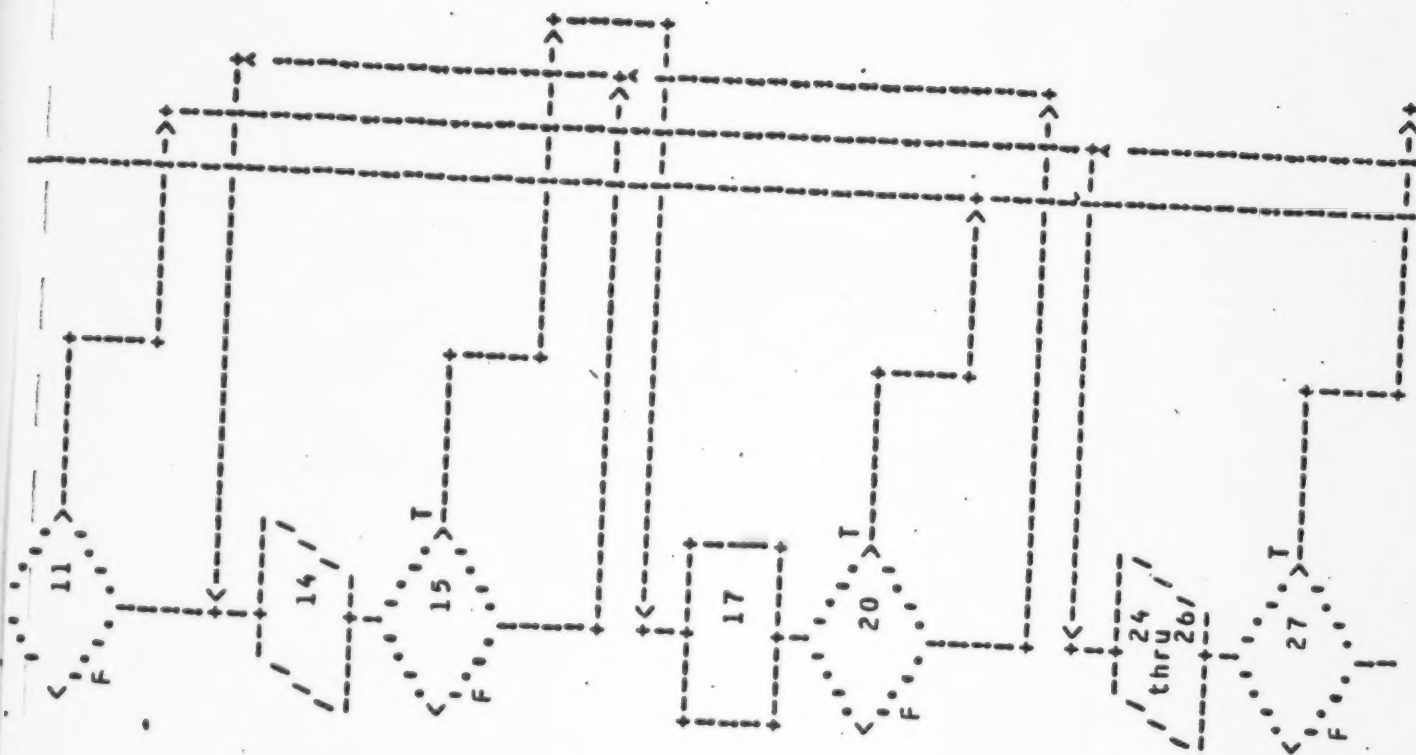
```

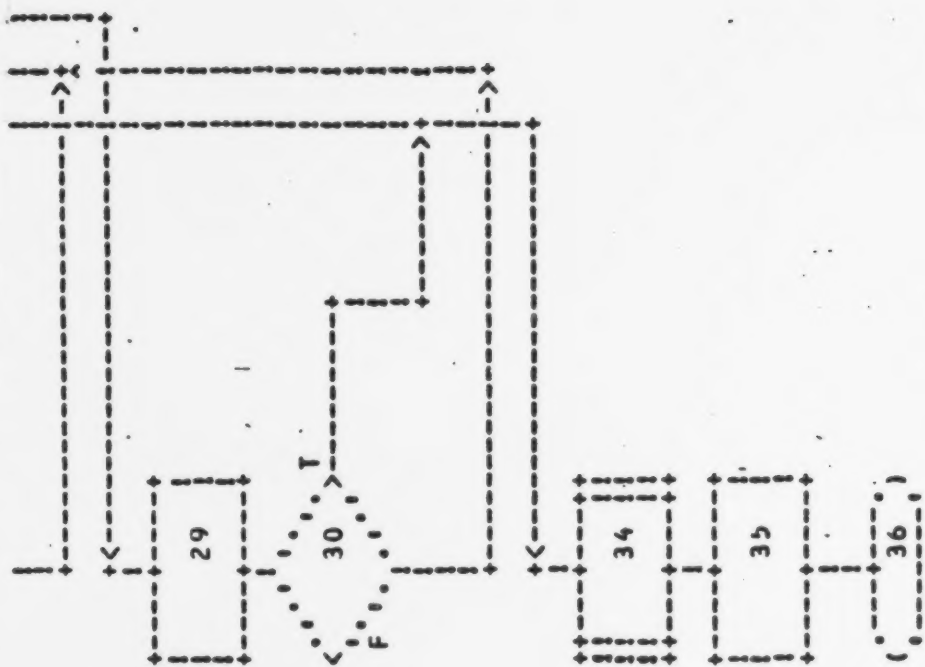
COMMON INDEX, IN, AN, INPUT(80), ITXT, IMDF, ITEM, IUUF, INN(11)
INDEX IS CURRENT FRAME NO.
KF=INDEX+1
CHECK IF THERE
IF(KF.EQ.IFRM) GO TO 50
CHECK TO SEE IF NEED TO GO BACK
IF(KF.GT.IFRM) GO TO 30
NEED TO GO AHEAD
READ(ITXT,2000) IAA TO 20
IF(IAA.EQ.2H22) GO TO 20
GO TO 10
KF=KF+1
ARE WE THERE
IF(KF.EQ.IFRM) GO TO 50
GO TO 10
BACK UP
BACKSPACE ITXT
BACKSPACE ITXT
READ(ITXT,2000) IAA TO 40
IF(IAA.EQ.2H22) GO TO 40
GO TO 30
KF=KF-1
IF(KF.EQ.IFRM) GO TO 50
GO TO 30
TELL THE WORLD
CALL TALK
INDEX=IFRM
RETURN
FORMAT(A2)
END

```



RECEIVED
10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38





SUBROUTINE REEDX

SUBROUTINE NAME: REEDX (NBIT)

REQUIRED SUBROUTINES:

ITEMS INPUT AND ASSOCIATED FORTRAN NAMES:

NBIT >0 implies expecting numeric response
INPUT - vector holding user input

ITEMS OUTPUT AND ASSOCIATED FORTRAN NAMES:

passed through COMMON:

IN - alpha response or integer portion of numeric response
AN - real part of numeric response
INPUT - user input (characteric vector)
INN - multiple integer input vector - each input number is an
element with INN () containing the number of input integers
passes through COMMON/VALS/ISW - numeric switch for any control words
input by user

REQUIRED OUTSIDE FILES (NAME, DESCRIPTION, FORMAT):

OPERATIONAL FEATURES SPECIFIC TO DEC-10 COMPUTER

```

1000  COMMON/INDEX, IN, AN, INPUT(80), ITXT, IHDF, ITEM, IOUF, INN(11), INUNT
1001  COMMON/VALS/ ISTEP, ISW
1002
1003  READ A STRING OF CHARACTERS UNDER A1 FORMAT,
1004  TRANSLATE THEM INTO A FLOATING POINT NUMBER, AND
1005  INTEGER OR ALPHA STRING AND SEARCH FOR CONTROL
1006  WORDS WITH APPROPRIATE ACTIONS TAKEN.
1007  NBUT.GT.0 IMPLIES EXPECTING NUMERIC RESPONSE
1008  DIMENSION ICHAR(14), IC(16), INPT(80)
1009  DATA ICHAR/1H ,1H.,1H+,1H-,1H0,1H1,1H2,1H3,1H4,1H5,1H6,
1010  1H7,1H8,1H9/
1011  DATA ICUN,IBLANK/1H^,1H /
1012  DATA IC/1HS,1HT,1H0,1HP,1HA,1HN,1HL,1HY,1HS,1HI,1HS,
1013  1HE,1HX,1HI,1HT/
1014
1015  INITIALIZE
1016  ISW=1
1017
1018  READ INPUT FROM USER
1019  READ(INUNT,2020) INPUT
1020  IFIELD=1
1021  ISGN=1
1022  IBASE=0
1023  IDEC=0
1024  IN=0
1025  AN=0.0
1026  DO 20 I=1,11
1027     INN(I)=0
1028     CONTINUE
1029
1030  LOOK AT THE EACH CHARACTER OF INPUT
1031  DO 250 IPDS=1,21
1032     INPTCH=INPUT(IPDS)
1033     DO 30 ICHSUB=1,14
1034        IF(INPTCH.EQ.ICHAR(ICHSUB)) GO TO 150
1035        CONTINUE
1036
1037  GETTING HERE IMPLIES ALPHA INPUT
1038  CHECK FOR SPECIFIC CHARACTERS
1039  DO 40 J=1,4
1040     IF(INPT(J).NE.IC(J)) GO TO 100
1041     CONTINUE
1042
1043  FOUND STOP
1044  PRESENT DIRECTORY OF OPTIONS
1045  WRITE(IOUF,2050)
1046
1047  READ USER OPTION INPUT
1048  READ(INUNT,2030) IDIR
1049  IF(IDIR.GT.4.OR.IDIR.LT.1) GO TO 50
1050  GO TO (60,60,70,80),IDIR
1051  ISW=2
1052  GO TO 90
1053  ISW=3
1054  GO TO 90
1055  ISW=4
1056  GO TO 90
1057  CONTINUE
1058  RETURN
1059  DO 110 J=1,8

```



```

3  IF(INPUT(J).NE.IC(J+4)) GO TO 120
4  CONTINUE
5  FOUND ANALYSIS
6  PRESENT DIRECTORY OF OPTIONS
7  DO 130 J=1,4
8  IF(INPUT(J).NE.IC(J+12)) GO TO 140
9  CONTINUE
10 FOUND EXIT
11 BRANCH TO PRINTING OF STOP DIRECTORY
12 GO TO 50
13 ALPHA STRING IN INPUT
14 CONTINUE
15 CHECK IF SHOULD BE NUMERIC RESPONSE
16 IF(INBIT.GT.0) GO TO 320
17 RETURN
18 CHECK CHARACTER AND WHERE TO PUT IT
19 IF(ICHSUB.LE.4) GO TO (160,170,180,190), ICHSUB
20
21 DIGIT FOUND
22 GO TO (200,240,230), IFIELD
23
24 BLANK FOUND
25 GO TO (250,260,260), IFIELD
26
27 PERIOD FOUND
28 GO TO (200,220,290), IFIELD
29
30 PLUS FOUND
31 GO TO (220,290,290), IFIELD
32
33 MINUS FOUND
34 GO TO (210,290,290), IFIELD
35 IFIELD=IFIELD+1
36 GO TO 150
37 ISGN=-1
38 IFIELD=IFIELD+1
39 GO TO 250
40 IDEC=IDEC+1
41 IDIG=IDIG+1
42 IBASE=10*IBASE+ICHSUB-5
43 GO TO 250
44 CONTINUE
45
46 ALL CHARACTERS EXAMINED CHECK FOR ALL BLANKS
47 IF(IFIELD.EQ.1) RETURN
48
49 CHECK FOR NUMBER IN ONLY FIRST 20 COLS.
50 IPOB=21
51 GO TO 290
52
53 TERMINATING BLANK FOUND
54 CHECK FOR IMBEDDED BLANK
55 DO 270 I=1,20
56 IF(INPUT(I).NE.IBLANK) GO TO 330
57 CONTINUE
58 IF(IDIG.GT.0) GO TO 280
59
60
61
62
63
64
65
66
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95
96
97
98
99
100
101
102
103
104
105
106
107
108
109
110
111
112
113
114
115
116
117
118
119
120
121
122
123
124

```

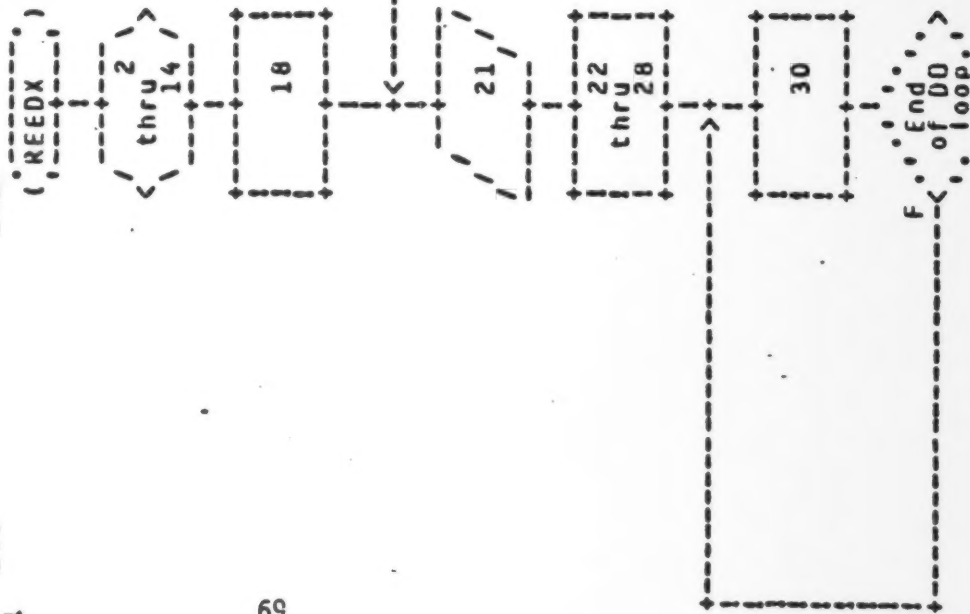
```

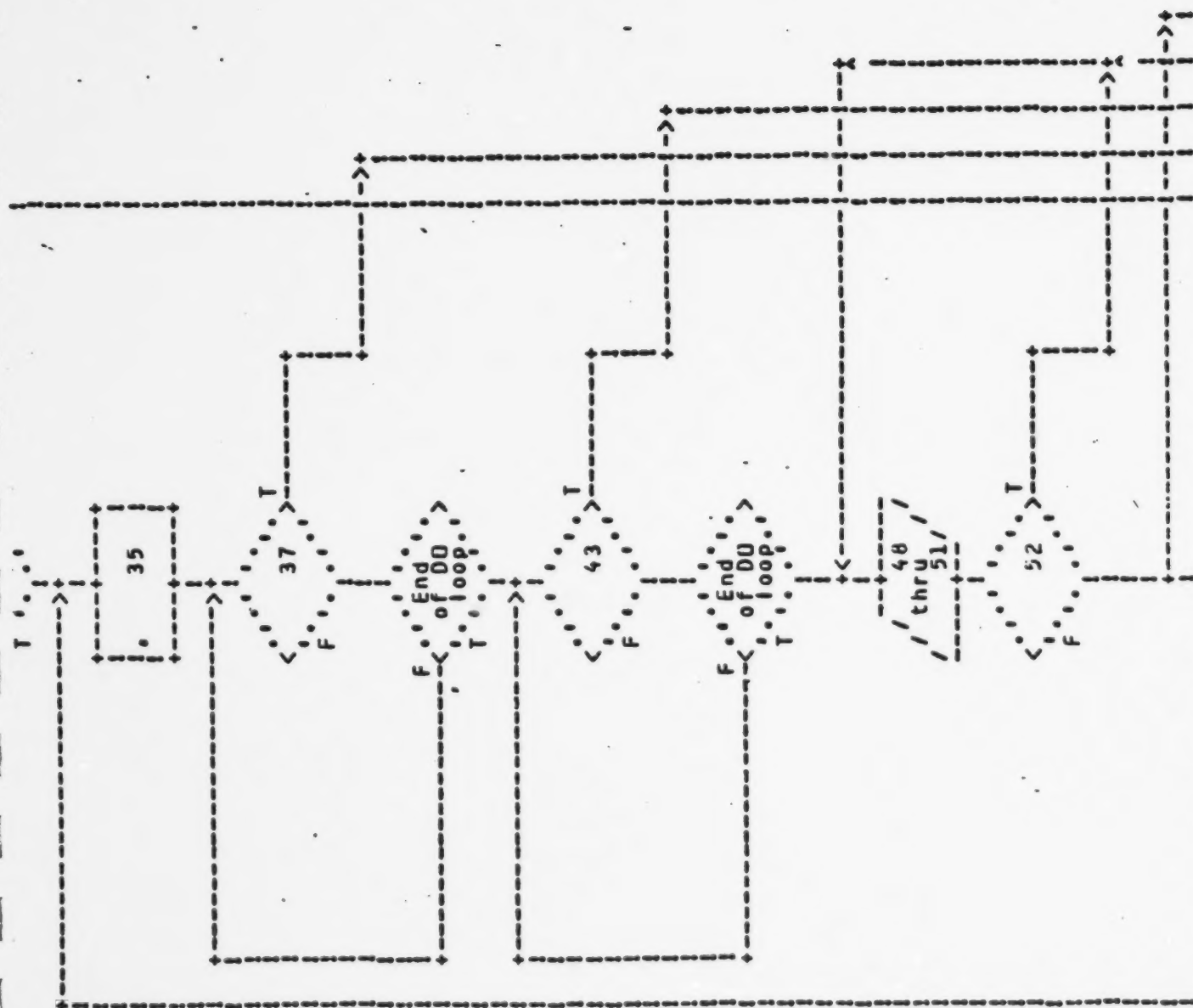
1207 C--- NO DIGITS
1208 IBASE=1
1209 IDIG=1
1210
1211 C--- CHECK FOR NON-INTEGER
1212 290 IIX=--IOEC
1213 IBASE=ISGN*IBASE
1214 IF(IIX.LT.U) GO TO 300
1215
1216 C--- GET THE INTEGER VALUE
1217 I=IBASE*10*IIX
1218 AN=FLUAT(I)
1219 IN=AN
1220 GO TO 310
1221
1222 C--- WRITE A NOTE FOR BAD CHARACTER
1223 290 WRITE(IOUT,2000)
1224 GO TO 320
1225
1226 C--- GET THE FLUATING POINT NUMBER
1227 300 AN=FLUAT(IBASE)*10.0*IIX
1228 IN=AN
1229 RETURN
1230
1231 C--- REQUEST INPUT AGAIN
1232 320 IF(NBIT.GT.0) WRITE(IOUT,2010)
1233 WRITE(IOUT,2000)
1234 GO TO 10
1235
1236 C--- STRUCTURE INPT VECTOR
1237 330 CONTINUE
1238 DO 360 I=1,80
1239   340 JJ=1,14
1240   IF(INPUT(I).EQ.ICHR(JJ)) GO TO 350
1241   CONTINUE
1242   IF(JJ.NE.1) INPT(I)=JJ-5
1243   IF(JJ.EQ.1) INPT(I)=1H
1244   CONTINUE
1245
1246 C--- LOAD SEQUENCE OF NUMBERS INTO INN'
1247 K=1
1248 IX=0
1249 IF(IX.GT.80) GO TO 400
1250 IF(INN(K)-INN(K)*10+INPT(IX))
1251   INN(K)=K
1252   IX=IX+1
1253   IF(IX.GT.80) GO TO 400
1254   IF(INPT(IX).EQ.1H) GO TO 390
1255   GO TO 380
1256   K=K+1
1257   GO TO 370
1258
1259 390 CONTINUE
1260
1261 C--- CHECK TO SEE IF ANY NUMBERS GREATER THAN 20
1262 DO 410 I=1,10
1263   IF(INN(I).GT.20) GO TO 420
1264   CONTINUE
1265 410 RETURN
1266
1267 C

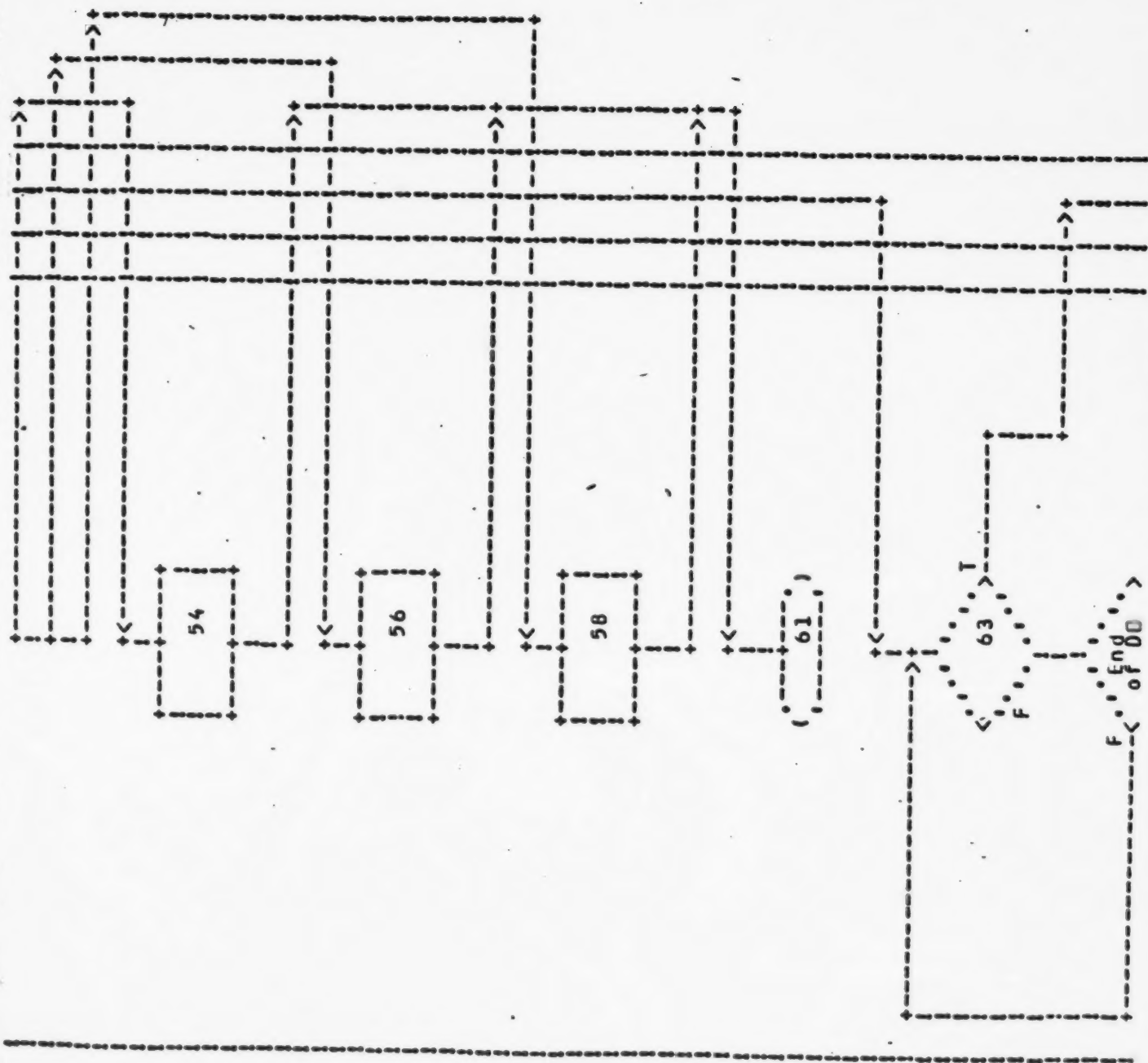
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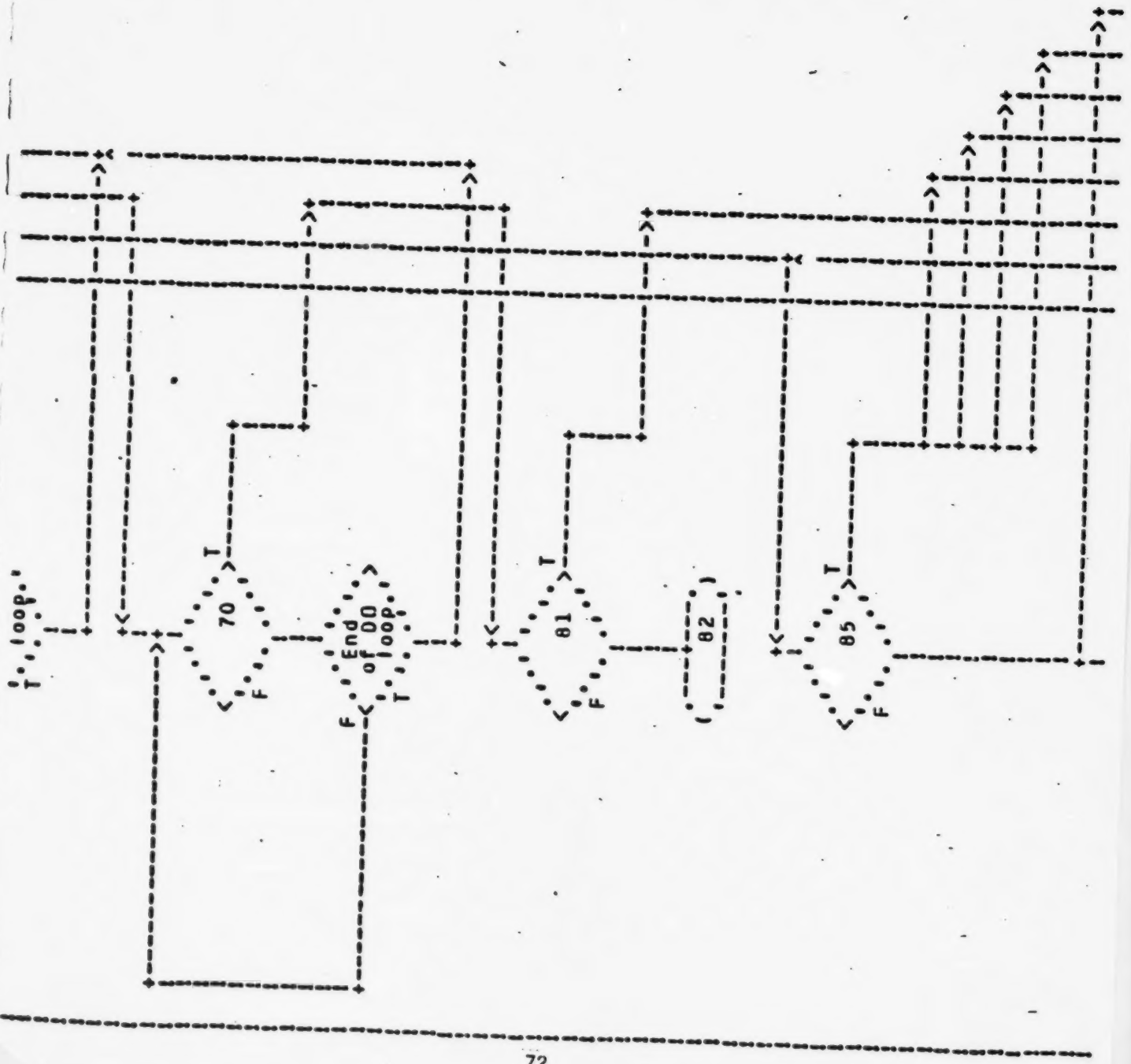
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6-420
WRITE (10U1,2040)
WRITE (10U1,2000)
GO TO 10
2000 FURMAT(14H ??? RE-ENTER)
2010 FURMAT(44H FOUND ALPHA WHEN EXPECTING NUMERIC RESPONSE)
2020 FURMAT(40A1)
2030 FURMAT(11)
2040 FURMAT(44H INDIVIDUAL NUMBER IN STRING GREATER THAN 20)
2050 FURMAT(1H //
167H PLEASE SELECT ONE OF THE FOLLOWING AND TYPE THE
2 ASSOCIATED NUMBER//
360H 1 - STOP EXECUTION OF THIS STEP AND RETURN TO THE
4 DIRECTOR//54H OF AVAILABLE STEPS IN THE MONITORING
5 METHODOLOGY//
636H 2 - STOP EXECUTION OF THE PROGRAM.//
745H 3 - PERFORM DATA ANALYSIS BEFORE CONTINUING.//
834H 4 - INSERT COMMENTS INTO THE MDF.)
END

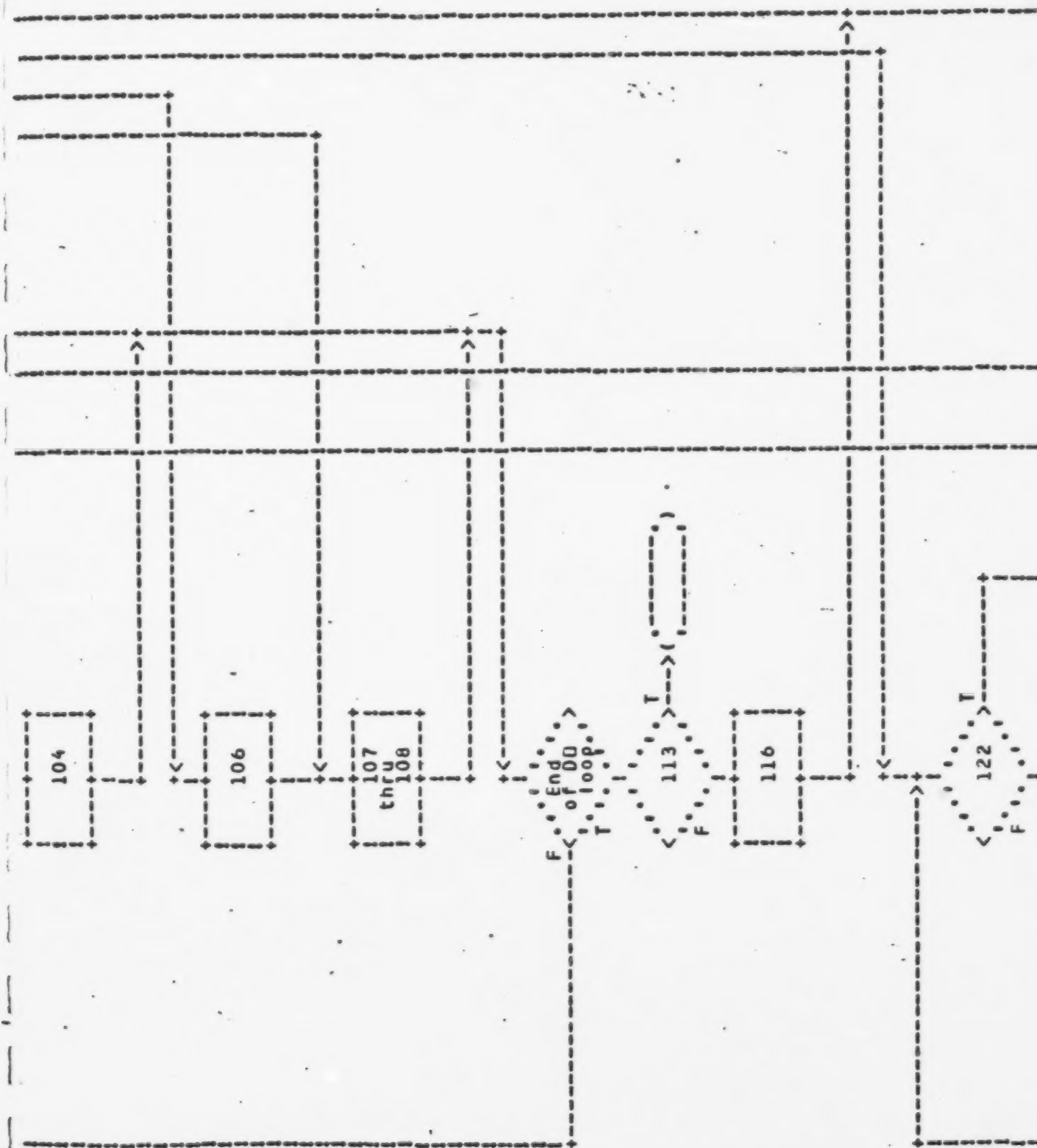


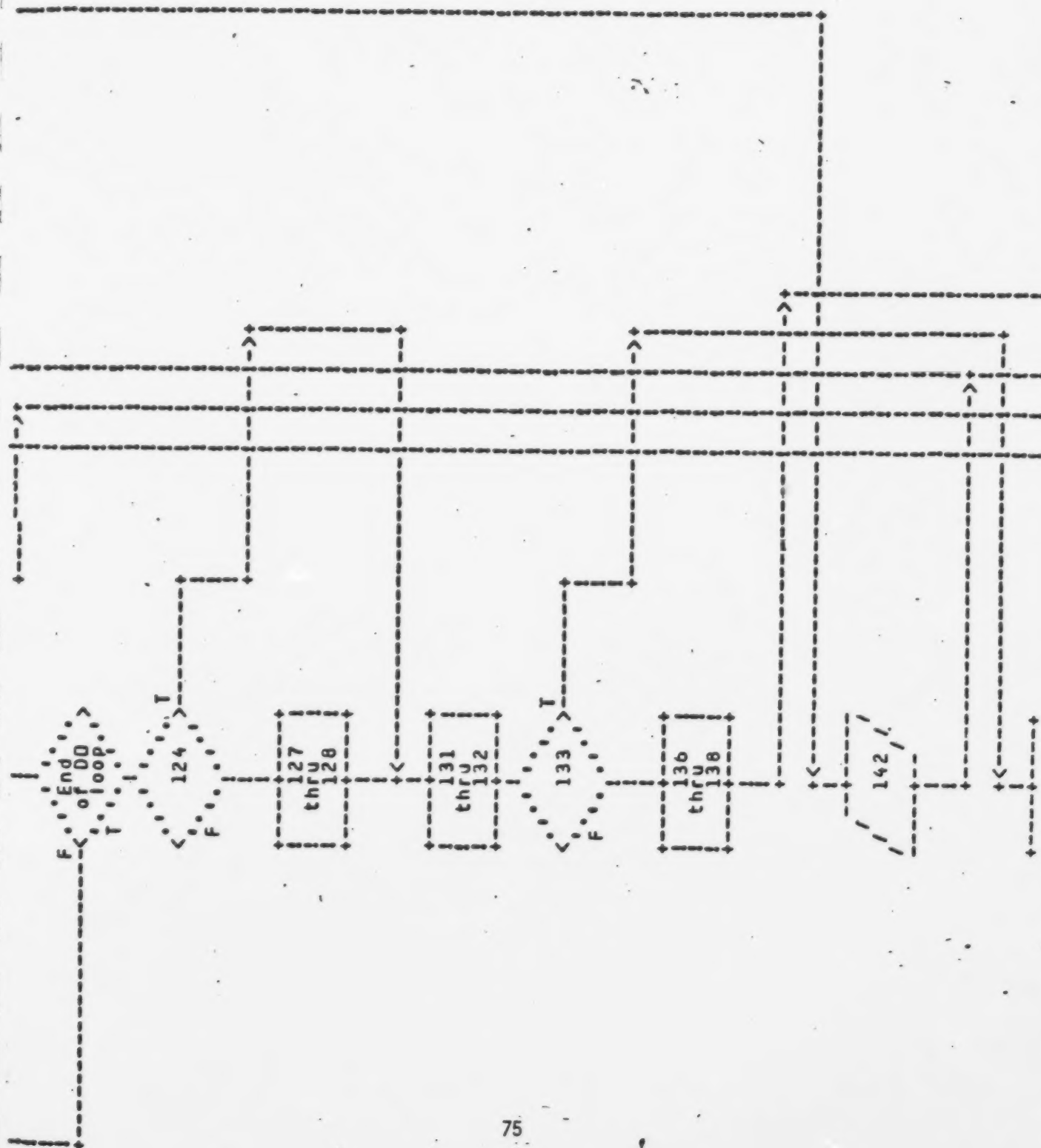


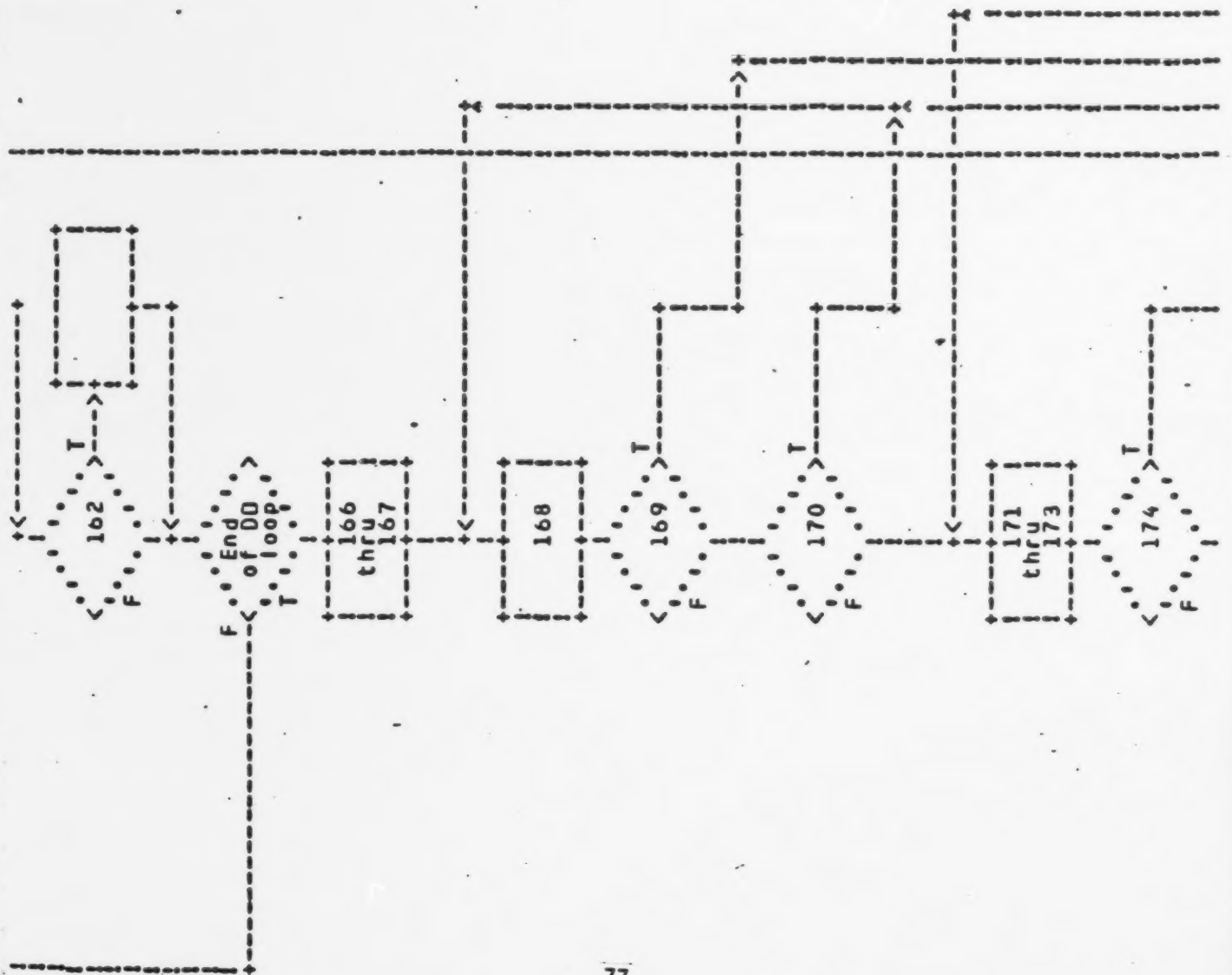


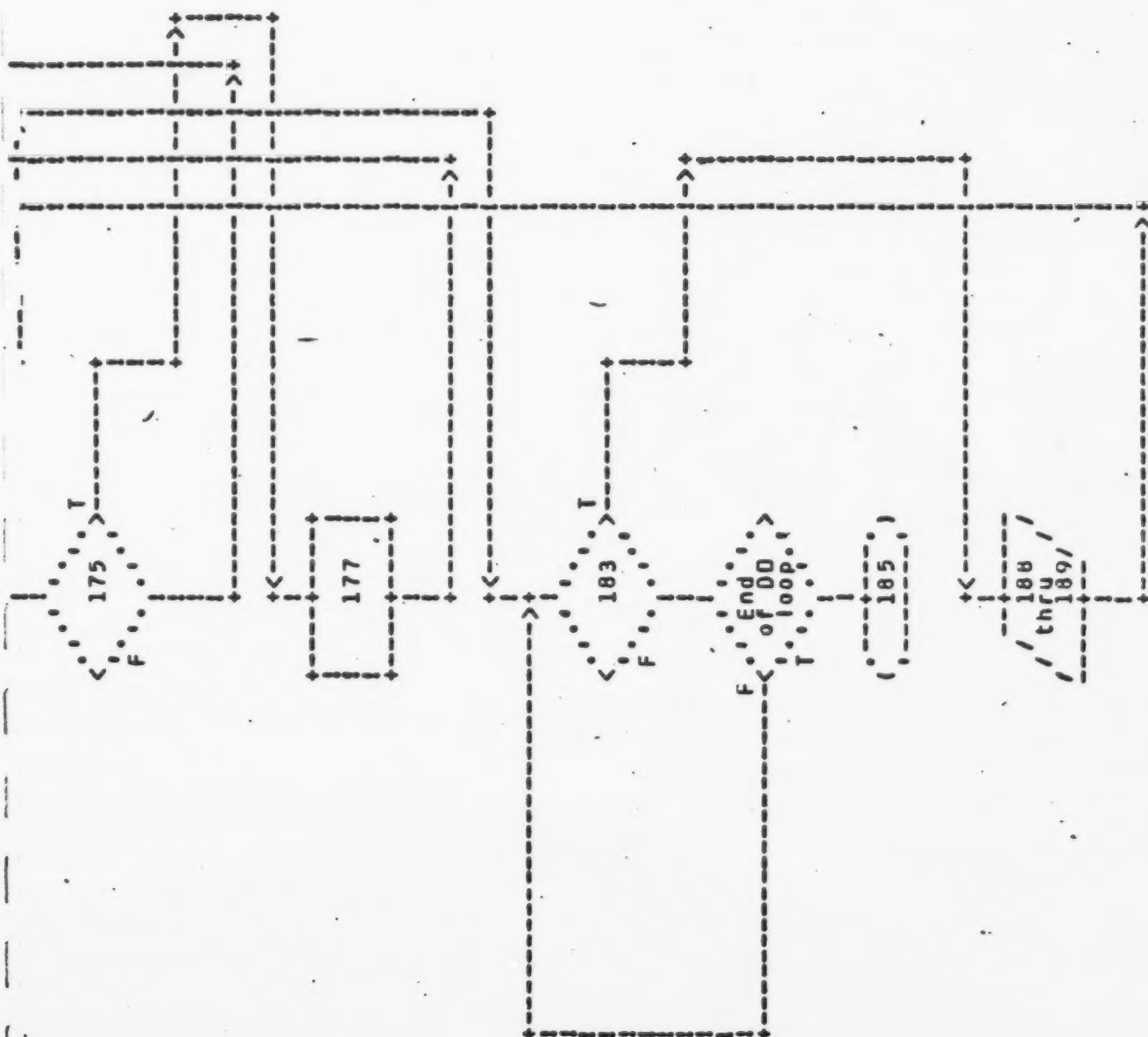












SUBROUTINE EXTND

SUBROUTINE NAME: EXTND (IX, IBIT, IFRM)

REQUIRED SUBROUTINES:

ITEMS INPUT AND ASSOCIATED FORTRAN NAMES:

IX - step number
IBIT = 0 get ready to extend
 = 1 cover up material and continue
IFRM - frame to branch to in order to finish step

ITEMS OUTPUT AND ASSOCIATED FORTRAN NAMES:

line by line addition to step in MDF.30.DAT

REQUIRED OUTSIDE FILES (NAME, DESCRIPTION, FORMAT):

IMDF - monitoring design file - MDF30.DAT
ITEM - monitoring design scratch file - MDF30.TEM

OPERATIONAL FEATURES SPECIFIC TO DEC-10 COMPUTER:

```

SUBROUTINE EXIND(IX,IBIT,IFRM)
  IX IS STEP NO.  IBIT=0 GET READY TO EXTEND
  IBIT=1 COVER UP ADDED MATERIAL AND CONTINUE
  IFRM IS FRAME TO BRANCH TO TO FILL STEP
  COMMON INDEX,IN,AN,INPUT(80),ITX1,IMDF,ITEM,INNT,INN(11),INUNT
  DIMENSION AA(40),AB(16),AC(9)
  DATA AC/2H01,2H02,2H03,2H04,2H05,2H06,2H07,2H08,2H09/
  ASTEP=AC(IX)
  IF(1BIT.GT.0) GO TO 80
  IREC=0

  READ RECORD ON MDF
  READ(IMDF,2040,END=30) (AA(I),I=1,2)
  IREC=IREC+1

  CHECK FOR CODE
  IF(AA(1).EQ.2H99.AND.AA(2).EQ.2H99) GO TO 71
  IF(AA(1).EQ.2H11.AND.AA(2).EQ.ASTEP) GO TO 70
  IF(AA(1).EQ.2H55.AND.AA(2).EQ.ASTEP) GO TO 40
  GO TO 10

  STEP IS ALREADY FINISHED
  WRITE(IOUT,2000) ASTEP
  REWIND IMDF
  RETURN

  END OF FILE FOUND ON MAIN FILE
  WRITE(IOUT,2010)
  REWIND IMDF
  RETURN

  AT END OF FRAGMENT IN STEP
  BACKSPACE IMDF
  READ(IMDF,2020) IFRM

  TRANSFER INFO TO MDF,TEM LINE BY LINE
  READ(IMDF,2030,END=60) AB
  WRITE(ITEM,2030) AB
  GO TO 50
  REWIND IMDF
  REWIND ITEM

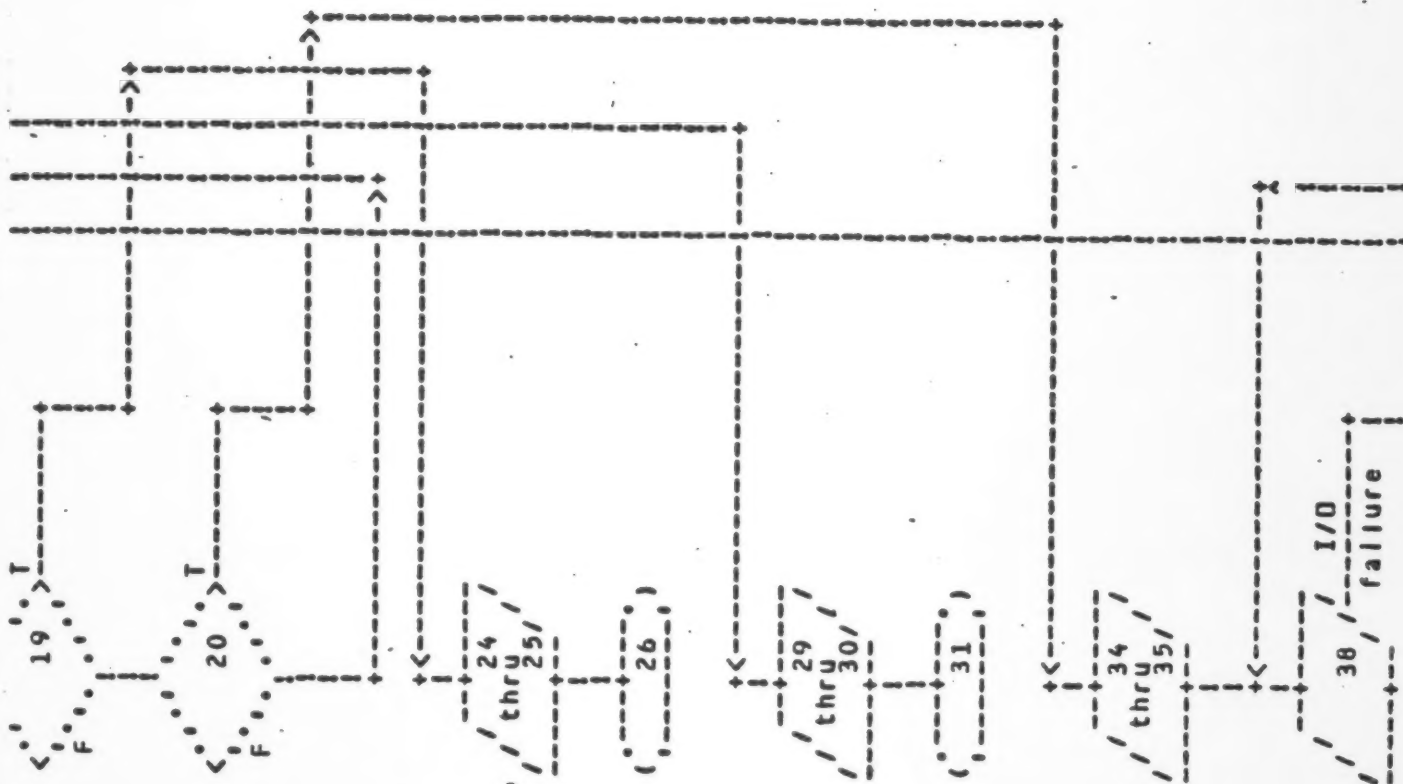
  GET TO POSITION TO ADD MATERIAL TO MDF
  DO 70 I=1,IREC
    SKIP RECORD IMDF
    CONTINUE
  70

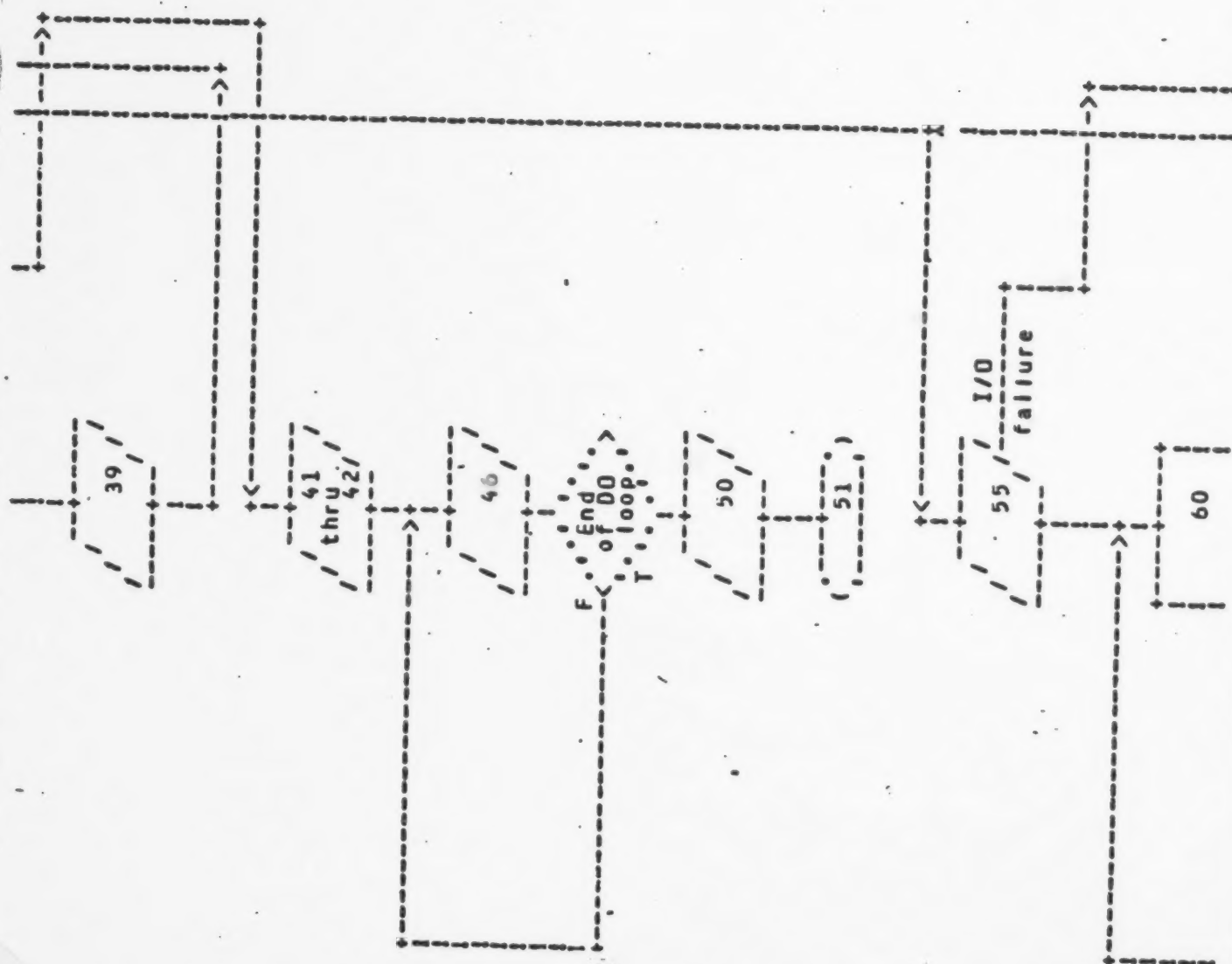
  READY TO ADD STEP FRAGMENT
  BACKSPACE IMDF
  RETURN

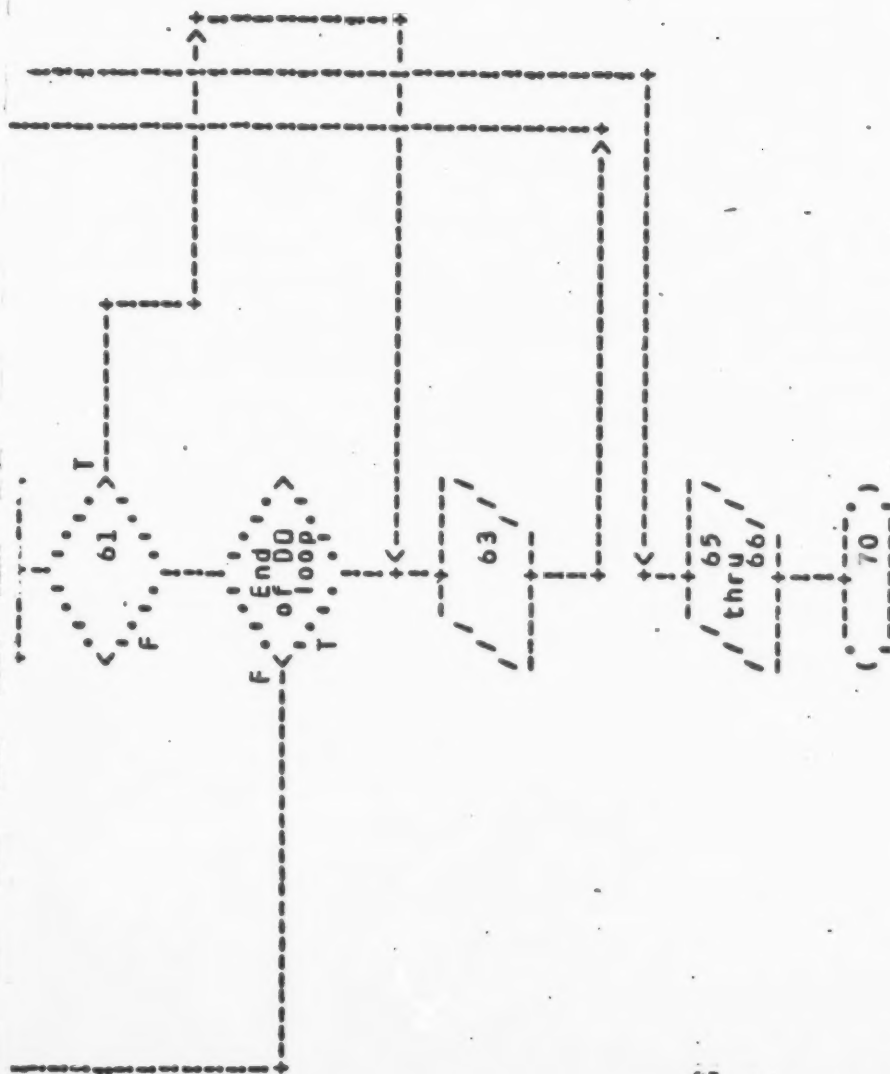
  AT END OF INSERT
  CLPY MATERIAL BACK TO MDF FROM SCRATCH FILE
  READ(ITEM,2030,END=110) AB

  FIND END OF LINE
  GET RID OF TRAILING BLANKS
  DO 90 J=1,16
    KK=17-J
    IF(AB(KK).NE.5H) GO TO 100
    CONTINUE
  90

```





SUBROUTINE COPIX

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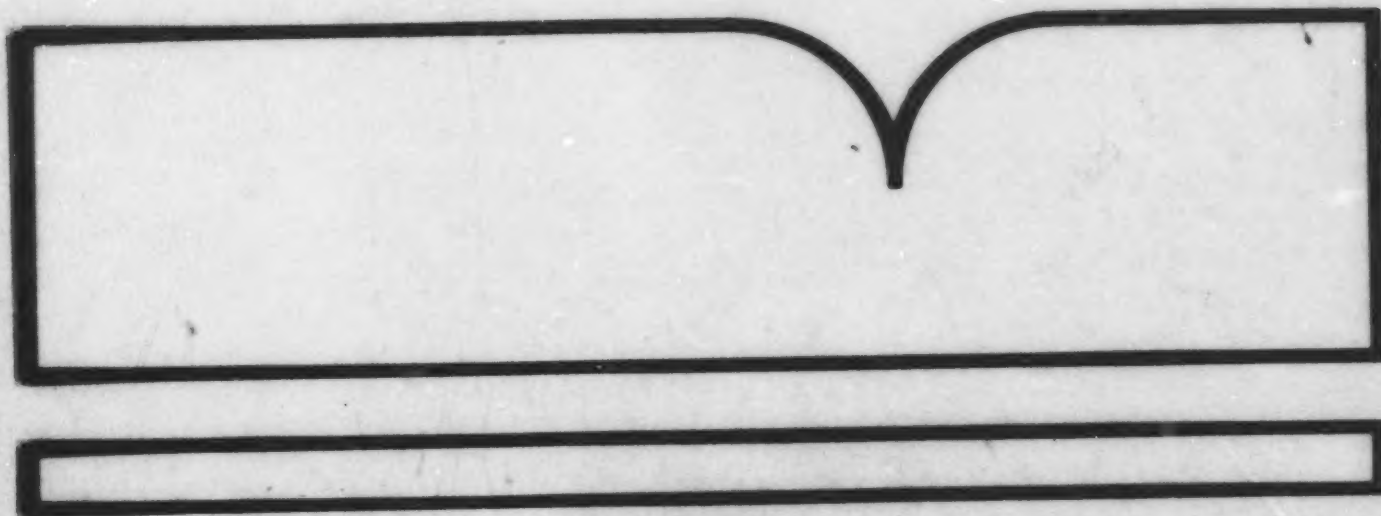
**Survey of Industrial Applications of
Vapor-Phase Activated-Carbon Adsorption
for Control of Pollutant Compounds from
Manufacture of Organic Compounds**

**IT Envirosience, Inc.
Knoxville, TN**

Prepared for

**Industrial Environmental Research Lab.
Cincinnati, OH**

Apr 83



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**SURVEY OF INDUSTRIAL APPLICATIONS OF VAPOR-PHASE ACTIVATED-CARBON
ADSORPTION FOR CONTROL OF POLLUTANT COMPOUNDS FROM MANUFACTURE OF
ORGANIC COMPOUNDS**

by

Farrel D. Hobbs, Charles S. Parmele, and Douglas A. Barton
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9041 Executive Park Drive
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Contract No. 68-03-2568
Task No. T7009

Project Officer

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TECHNICAL REPORT DATA (Please read Instructions on the reverse before completing)		
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4. TITLE AND SUBTITLE Survey of Industrial Applications of Vapor-Phase Activated-Carbon Adsorption for Control of Pollutant Compounds from Manufacture of Organic Compounds	5. REPORT DATE April 1983	
7. AUTHOR(S) F. D. Hobbs, C. S. Parmele, D. A. Barton	6. PERFORMING ORGANIZATION CODE	
9. PERFORMING ORGANIZATION NAME AND ADDRESS IT ENVIROSCIENCE, INC. 9041 Executive Park Drive Knoxville, TN 37923	8. PERFORMING ORGANIZATION REPORT NO.	
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16. ABSTRACT This study covers industrial use of activated carbon for vapor-phase applications. A listing of over 700 applications of vapor-phase carbon systems is made available for use in identifying sites where a given compound is being removed.	14. SPONSORING AGENCY CODE EPA/600/12	
17. KEY WORDS AND DOCUMENT ANALYSIS		
a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Industrial waste treatment Organic compounds Hydrocarbons	Air Pollution Control Vapor-phase adsorption Wastewater Treatment Carbon adsorption	138 68A
18. DISTRIBUTION STATEMENT Release to Public	19. SECURITY CLASS (This Report) Unclassified	21. NO. OF PAGES 53
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FOREWORD

When energy and material resources are extracted, processed, converted, and used, the related polluttional impacts on our environment and even on our health often require that new and increasingly more efficient pollution control methods be used. The Industrial Environmental Research Laboratory - Cincinnati (IERL-Ci) assists in developing and demonstrating new and improved methodologies that will meet these needs both efficiently and economically.

The objective of this study was to gather performance data on the current uses of activated carbon for treating both industrial wastewaters and vapor emissions from the manufacture and use of organic chemicals. This information is contained in two reports: one dealing with aqueous-phase applications and one with vapor-phase applications. Much of the basic information about carbon adsorption has appeared elsewhere in a variety of sources; these reports serve the purpose of bringing together the information in a single source. The data compiled by this survey can also be used to identify sites for sampling.

For further information on this subject, contact the Industrial Environmental Research Laboratory, Cincinnati, Ohio 45268

David G. Stephan
Director
Industrial Environmental Research Laboratory
Cincinnati, Ohio

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ABSTRACT

Vapor-phase activated-carbon adsorption has frequently been used to recover solvents and/or control emissions from processes that manufacture or use organic chemicals. This report presents the results of a survey of the applications of vapor-phase adsorption. A separate report on the survey of aqueous-phase applications of activated carbon was prepared concurrently.

Use of adsorption is not restricted to the synthetic organic chemicals manufacturers. Nearly 760 applications of vapor-phase adsorption were found by reviewing state and EPA files, the open literature, government reports, vendor literature and information from companies that manufacture or use organic chemicals. Although a wide variety of applications were found, the data base that would allow assessment of the effectiveness and cost of this technology is very incomplete. There are probably many applications that were not identified by this survey because there is evidence that most of the data bases that were searched are incomplete. The shortcomings of the data bases are also illustrated by the fact that data for both the flowrate and the compounds being adsorbed were available for only 25% of the applications.

A limited amount of followup showed that a significant amount of effort would be required to fill the gaps in the data base. This report summarizes the information collected, the references used and contacts made to gather these data in order to facilitate any followup activities that may be done in the future.

Even though this survey did not produce an exhaustive compilation of cost and performance data for full-scale applications of adsorption, no sources of data contained a more complete listing of applications than the one found in this report.

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APPENDIX

A. SUMMARY OF CONTACTS MADE

I. INTRODUCTION

The effluent guidelines which are to be promulgated by the EPA are to also identify Best Available Treatment for the priority pollutants. Activated carbon adsorption is the wastewater treatment technology most often identified as being capable of achieving the low effluent concentrations being considered. Similarly, vapor-phase activated-carbon adsorption has been promoted for control of atmospheric emissions of organic chemicals because it can often achieve the low effluent concentrations and/or high removal efficiencies desired.

Although a lot of data have been generated on the performance of activated carbon to remove specific components from wastewater or air, these data are not summarized in one reference.

The goal of this task order is to review the current and planned uses of activated carbon for treating wastewaters and emissions from the manufacture of organic chemicals, to identify data gaps, and to define programs to fill in these gaps. This information would then become part of the technical data base for use by the EPA in identifying treatment technologies for both wastewater treatment and control of atmospheric emissions.

This report summarizes only the results of the survey of the applications of vapor-phase adsorption. The results of the survey of aqueous-phase adsorption are included in a separate report because there was very little overlap between the two surveys.

II. CONCLUSIONS

- A. Vapor-phase adsorption has been applied for controlling emissions and/or solvent recovery in most of the industries that manufacture or use organic chemicals. This survey identified nearly 760 applications with flowrates ranging from 0.5 CFM to 375,000 CFM. (Flowrates are given in English units. Converting the English units used by all sources of data to metric units would only add confusion.)
- B. The condition of the data bases used as resources for this survey makes it very difficult to estimate how many adsorption applications were not identified by this survey. All of the state and EPA data bases are currently incomplete. Some data files are being computerized to facilitate data retrieval. Some data files have already been computerized but they are only as useful and complete as the criteria used to decide which data are included in them. When these data files are reviewed, corrected, and updated they will become more useful sources of information.
- C. No generalizations can be made on the effectiveness or economics of adsorption as a control device because there are very little data available anywhere on performance and costs. In many cases these data have not been generated yet. When these data have been generated in the past, they have been unavailable because the company using adsorption has restricted publication of these "proprietary" or "confidential" data.
- D. Even though the state and EPA files are incomplete, they are the best sources of data on where adsorption has been applied because very little information has been published in the open literature. Companies using adsorption are often reluctant to provide data, particularly performance and cost data, because they consider these data to be confidential. Carbon suppliers and equipment vendors were more cooperative but they were often restricted by confidentiality agreements with their clients.
- E. Despite references by many people to the existence of a complete listing of full-scale applications of vapor-phase adsorption, no source of data had a more comprehensive list than the list compiled by this survey.

- F. The effort required to survey vapor-phase applications was not an incremental addition to the effort required for surveying aqueous-phase applications because the sources of data for vapor-phase applications to control emissions are completely different from the sources of data for aqueous-phase applications to treat wastewater.

III. RECOMMENDATIONS

- A. More performance and cost data are needed to assess the use of vapor-phase adsorption to control emissions but compiling the necessary data base will not require collecting data for all of the applications listed in Table 1. However, Table 1 should be used as a screening tool to identify applications for which more data are desired and to establish priorities in collecting the data.
- B. Where existing data on performance and costs are available, they should be scrutinized for accuracy. Many entries in state and EPA files are based on unvalidated engineering estimates incorporated in permit applications. Where data are unavailable, they should be generated using sound analytical procedures.
- C. One source of data that should be incorporated in followup activities is the information in the Standards Development Branch, Emissions Standards and Engineering Division, Office of Air Quality Planning and Standards, US EPA, Research Triangle Park, NC. Data from this source were not accessed for this survey because the source was identified at the very end of the data gathering activity.
- D. As the data bases being compiled by the state and EPA offices become established and mature, more cross-checking between offices covering the same geographical area should be done to make these data bases more complete and useful.

IV. SURVEY METHODOLOGY

In order to define the effectiveness of full-scale vapor-phase activated-carbon adsorption, a wide variety of data was desired including the following:

1. type and amount of contaminant removed
2. removal efficiency
3. emission flowrate
4. pretreatment requirements
5. number of beds
6. bed dimensions
7. bed configuration
8. superficial velocity
9. type of carbon
10. carbon inventory (in beds only)
11. carbon exhaustion rate
12. regeneration technique
13. carbon loss/regeneration cycle
14. utilities cost
15. operating cost
16. capital costs

These data were sought from a wide variety of sources, including carbon vendors, industrial users of activated carbon, the open literature, government documents, and state and EPA files.

As with the survey of aqueous-phase applications, early attempts to extract information from carbon suppliers, equipment vendors, and companies believed to be using adsorption were very inefficient in terms of the large effort required to gather a small amount of data. Therefore, the survey focused on sources that (1) contained data already in the public domain and (2) were likely to identify many applications at one time. Apparently, very few published references on applications of full-scale vapor-phase adsorption exist because the Lockheed Dialog computerized search of the literature identified very few applications. Most of the applications were identified via searches (often by computer) of some state and federal environmental agencies' files of emission control devices.

This is in direct contrast to the results of survey of full-scale applications of aqueous-phase adsorption for wastewater treatment where very little data were available from government files.

The survey was not limited to applications in the organic chemicals manufacturing industry because the value of the data on full-scale applications is not a function of the industry in which adsorption is used.

The sources contacted during this survey are summarized in Appendix A in order to facilitate any followup activities.

V. RESULTS OF THE SURVEY

Although this survey represents a compilation and review of many data sources, it does not completely describe all of the full-scale vapor-phase applications of activated carbon. The success of this survey was limited by several factors:

1. Identification of all full-scale applications was not possible. Some companies view use of adsorption as proprietary and will not divulge any information. Carbon suppliers and equipment vendors were more cooperative but they were often unable to identify unpublished applications because of secrecy agreements with their clients.
2. The continually expanding data bases and ways to access information contained in these data bases make an exhaustive search very difficult. In fact, most of the searches cannot be considered exhaustive because there were numerous examples where known applications of adsorption were not identified by computerized searches. This was because the applications were not included in the data base.

This problem will be partially solved as more computerized data bases are established and as gaps in existing data bases are identified and filled. There were several examples where results of searches of state or regional EPA files did not overlap completely with a search of the Federal files for the same geographic area. For example, the one application of vapor-phase adsorption reported in Illinois by the National Emissions Data System was not among the 141 applications reported by the State of Illinois. A small amount of followup showed that these discrepancies could not be easily resolved.

3. Data for the identified applications are not complete especially with respect to cost data and to removal efficiencies for specific components. In many cases the data are simply unavailable because the adsorption units have been installed on the vents and operated automatically with little or no operator attention. Very little specific component analyses have been done to verify the estimated removal efficiencies. When data are available, they are often classified as confidential.

Table 1 lists alphabetically, by state, all of the full-scale applications of vapor-phase adsorption that were identified by this survey. The data in Table 1 were entered in an IBM Office Systems 6 Information Processor in order to expedite the alphabetization of the data base while additions and corrections were made. These data will remain in storage for use in the future. The references for Table 1 are listed in Table 2. This survey is known to be incomplete and it is difficult to estimate how many more adsorbers are in service because of the known deficiencies of the sources of these data.

The shortcomings of most of the data bases used to compile Table 1 are illustrated by the many gaps in the data just for flowrate and/or identity of the compounds in the vents being controlled. (Flowrates are given in English units because all of the sources of data used English units.) Only 25% of the 760 entries for the full-scale applications identified have data on both flowrate and the compounds being adsorbed.

Significant followup will be required to fill the many data gaps in Table 1 and to resolve the many suspected discrepancies. The most prominent kind of discrepancy is whether similar or identical entries in Table 1 refer to more than one similar or identical adsorption system or are really duplicate references to a single application. Multiple references to a single application often caused by supplying slightly different information such as flow, the compounds being adsorbed, or location (city vs county or major city vs suburb) to different regulatory agencies. An attempt was made to correct obvious errors and/or to eliminate duplicate references but this was not always straightforward. As an example it is not clear how many, if any at all, of the 12 adsorption systems listed by NEDS (Reference 1) for the Endicott Labs in Endicott, NY are the same as the 25 units listed by the State of New York (Reference 20) for IBM Corporation in Endicott, NY. On the other hand, it cannot be assumed that similar entries refer to only one application because there are numerous examples of identical adsorption units being installed to control emissions from parallel trains of equipment. Therefore, in most cases the entries in Table 1 have been extracted directly from the references even though they appear to be in error.

No performance or cost data are included in Table 1 because very little data were found. Several references warned that when these data were available,

TABLE 1. FULL-SCALE APPLICATIONS OF VAPOR-PHASE ADSORPTION

COMPANY	CITY/COUNTY	ST	SOURCE	CHEMICAL	FLOW (CFH)	REF. ^a
Sony Magnetic Prod	Houston Co.	AL	Surface Coating		10,000	1
Falleh-Lankro Corp.	Tuscaloosa	AL	Chem Mfg, Pesticides		105,000	1
Shell Oil Co.	Phoenix	AZ				10
Valley Industrial Services	Anaheim	CA	Dry Cleaning	Stoddard Solvent	8,400	23
Union Oil of California	Avila Beach	CA				10
Sands Drpsy	Burbank	CA	Dry Cleaning	Perchloroethylene		1
3M	Camrillo	CA	Surface Coating	Methyl ethyl ketone		1
3M	Camrillo	CA	Surface Coating	Toluene		1
3M	Camrillo	CA	Surface Coating			1
Atlantic Richfield	Carson	CA	Petroleum Refining (wastewater tank)			1
Golden Eagle Ref	Carson	CA	Petroleum Refining			1
Witco Chemical	Carson	CA	Linear Alkylbenzene Manufacture	Benzene, C10 Paraffin	20,000	11
USS Polyester	Colton	CA	Polyester Manufacture			27
USS Polyester	Colton	CA	Polyester and Glycols Manufacture			27
USS Polyester	Colton	CA	Chemical Manufacture			27
Four Corners Pipeline Co.	Corona	CA	Petroleum Storage			1
One Hour Martinizing	Cudahy	CA	Dry Cleaning	Stoddard Solvent		1
Chevron USA Inc.	El Segundo	CA	Wastewater Treatment	Sulfides	5600	28
Chevron USA Inc.	El Segundo	CA	Wastewater Treatment	Sulfides	5200	28
Chevron USA Inc.	El Segundo	CA	Sour Water Tank/Refinery	Hydrogen sulfide, Mercaptans	183	28
Thrifty Wash & Clean	Glendale	CA	Dry Cleaning	Stoddard Solvent		1
MovieLab-Hollywood	Hollywood	CA		1,1,1-Trichloroethane	160	33
Fashion Dry Cleaner	Lancaster	CA	Dry Cleaning	Stoddard Solvent		1
AnVac Chemical Corp	Los Angeles	CA		Dibromochloropropane	1800	30
Carriage Trade Cleaners	Los Angeles	CA	Dry Cleaning	Stoddard Solvent		1
Cascade Cleaners	Los Angeles	CA	Dry Cleaning	Perchloroethylene	1350-1450	29

(a) See Table 2 for listing of references.

(Continued)

TABLE 1 (Continued)

COMPANY	CITY/COUNTY	ST	SOURCE	CHEMICAL	FLOW (CFM)	REF
Consolidated Film	Los Angeles	CA	Degreasing	1,1,1-trichloroethane		1
Consolidated Film	Los Angeles	CA	Degreasing	1,1,1-trichloroethane		1
Consolidated Film	Los Angeles	CA	Degreasing	1,1,1-trichloroethane		1
Consolidated Film	Los Angeles	CA	Degreasing	1,1,1-trichloroethane		1
Consolidated Film	Los Angeles	CA	Degreasing	1,1,1-trichloroethane		1
Consolidated Film	Los Angeles	CA	Degreasing	1,1,1-trichloroethane		1
Deluxe Genl Inc.	Los Angeles	CA	Degreasing	1,1,1-trichloroethane		1
Deluxe Genl Inc.	Los Angeles	CA	Degreasing	1,1,1-trichloroethane		1
Deluxe Genl Inc.	Los Angeles	CA	Degreasing	1,1,1-trichloroethane		1
Deluxe Genl Inc.	Los Angeles	CA	Degreasing	1,1,1-trichloroethane		1
Deluxe Genl Inc.	Los Angeles	CA	Degreasing	1,1,1-trichloroethane	25,459	1
	Los Angeles	CA	Solid Waste Disposal			
	Los Angeles	CA	Single Chamber Incineration			
Deluxe Genl Inc.	Los Angeles	CA	Degreasing	1,1,1-trichloroethane		1
Deluxe Genl Inc.	Los Angeles	CA	Degreasing	1,1,1-trichloroethane		1
Factory Apron & Towel Supply Inc.	Los Angeles	CA	Dry Cleaning	Perchloroethylene	1350-1450	31
Gravure West	Los Angeles	CA		Toluene, VM&P Naphtha	90,000	12,17
Holiday Coin-Op	Los Angeles	CA	Dry Cleaning	Stoddard Solvent		1
Morge Laundry and Dry	Los Angeles	CA	Dry Cleaning	Stoddard Solvent		1
Park Cleaners	Los Angeles	CA	Dry Cleaning	Stoddard Solvent		1
PICO Clean Ctr	Los Angeles	CA	Dry Cleaning	Perchloroethylene		1
PICO Clean Ctr	Los Angeles	CA	Dry Cleaning	Perchloroethylene		1
Shell Oil Co.	Los Angeles	CA				10
Sloans Dry Cleaners	Los Angeles	CA	Dry Cleaning	Stoddard Solvent		1
Sloans Dry Cleaning	Los Angeles	CA	Dry Cleaning	Perchloroethylene		1
Sloans Dry Cleaning	Los Angeles	CA	Dry Cleaning	Perchloroethylene		1
Thrifty Dry Cleaner	Los Angeles	CA	Dry Cleaning	Stoddard Solvent		1
Velvetone Cleaners	Los Angeles	CA	Dry Cleaning	Stoddard Solvent		1

(Continued)

TABLE 1 (Continued)

COMPANY	CITY/COUNTY	ST	SOURCE	CHEMICAL	FLOW (CFH)	REF
Vernon Industrial	Los Angeles	CA	Dry Cleaning	Stoddard Solvent		1
Welchs Overl Clin	Los Angeles	CA	Dry Cleaning	Perchloroethylene		1
La Bar Sanitatin	Los Angeles Co.	CA	Dry Cleaning	Perchloroethylene		1
Alco-Gravure Inc.	North Hollywood	CA	Rotogravure			17
Britts Custom Clean	Paramount	CA	Dry Cleaning	Stoddard Solvent		1
B&B Cleaners	Pomona	CA	Dry Cleaning	Perchloroethylene		1
Wardrobe Cleaners	Redondo Beach	CA	Dry Cleaning	Stoddard Solvent		1
Stauffer Chemical Co.	Richmond (Stage)	CA	Ordram Manufacture	Ordram Odor Control	3000	32
Gates-Admiral/Indus	Riverside	CA	Dry Cleaning	Perchloroethylene	1000	1
Gates-Admiral/Indus	Riverside	CA	Dry Cleaning	Perchloroethylene	1000	1
Rohr Industries	Riverside	CA	Surface Coating	Perchloroethylene	5,000	1
Aminoil	Sacramento	CA				10
Arcata Graphics	San Jose	CA	Rotogravure			17
San Jose Graphics	San Jose	CA	Surface Coating			1
San Jose Graphics	San Jose	CA	Printing			1
San Jose Graphics	San Jose	CA	Surface coating			1
San Jose Graphics	San Jose	CA	Printing			1
Caterpillar Tractor Co.	San Leandro	CA	Degreasing	1,1,1-trichloroethane		1
Maxwell House	San Leandro	CA	Roast. Coffee, Surf. Cost., Thin. Solv.			1
Quick Clean Center	Santa Fe	CA	Dry Cleaning	Stoddard Solvent		1
Gulf Oil Co.	Santa Fe Springs	CA	LPG Odorant Loading			1
Aminoil	Stockton	CA				10
Del Amo Cleaners	Torrance	CA	Dry Cleaning	Stoddard Solvent		1
Arpsahoe Chemicals Inc.	Boulder	CO	Chemical Manufacture		21,000	1
IBM	Boulder	CO	Surface Coating		2200	1
IBM	Boulder	CO	Surface Coating		10,000	12
IBM	Boulder	CO	Surface Coating		57,727	1
IBM	Boulder	CO	Surface Coating		15,000	12

(Continued)

TABLE 1 (Continued)

COMPANY	CITY/COUNTY	ST	SOURCE	CHEMICAL	FLOW (CFH)	REF
Phillips Petroleum	Denver	CO				10
Eastman Kodak	Windsor	CO	Surface Coating		15,800	1
Chevron Oil Co.	Bridgeport	CT	Gas Loading			2
Chevron Oil Co.	Bridgeport	CT				2
Columbia Magnetics	Danbury	CT				2
Columbia Magnetics	Danbury	CT	Surface Coating			2
American Cyanamid	Glenbrook	CT	Mixing Kettles			2
American Cyanamid Co.	Glenbrook	CT	Reactors			2
Capital Magnetic Prod	Glenbrook	CT	Coating machines			2
Pfizer, Inc.	Groton	CT				2
Pfizer, Inc.	Groton	CT				2
Pfizer, Inc.	Groton	CT				2
Pfizer, Inc.	Groton	CT				2
Addressograph Multi Corp	Gulford	CT	Coating (Printing)			2
Addressograph Multi Corp	Gulford	CT	Coating (Printing)			2
Burning Division	Gulford	CT				2
Walters Belting Ind.	Middletown	CT	Coating (fabrics)			2
Walters Belting Ind.	Middletown	CT	Coating (fabrics)			2
Walters Belting Ind.	Middletown	CT	Coating (fabrics)			2
Walters Belting Ind.	Middletown	CT	Coating (fabrics)			2
Walters Belting Ind.	Middletown	CT	Coating (fabrics)			2
Macrasty Industries	New Britain	CT	Coating (fabrics)			2
The Stanley Works	New Britain	CT	Coating Oven			2
Mobil Oil Corp	New Haven	CT	Gas storage tanks			2
Mobil Oil Corp	New Haven	CT	Gas storage tanks			2
Mobil Oil Corp	New Haven	CT	Gas storage tanks			2
Mobil Oil Corp	New Haven	CT	Gas storage tanks			2
Mobil Oil Corp	New Haven	CT	Gas storage tanks			2

(Continued)

TABLE 1 (Continued)

COMPANY	CITY/COUNTY	ST	SOURCE	CHEMICAL	FLOW (CFM)	REF
General Electric Co.	Plainville	CT	Metal Surface Preparation			2
Chevron Oil Co.	Portland	CT	Gas Loading			2
American Cyanamid Co.	Wallingford	CT	Extruders			2
American Cyanamid Co.	Wallingford	CT	Polymer Manufacture			2
American Cyanamid Co.	Wallingford	CT	Thermoplastics Manufacture			2
Stanley Drapery Hardware	Wallingford	CT	Coating (coil)			2
The Stanley Works	Wallingford	CT	Metal Surface Preparation			2
Armstrong Rubber Co.	West Haven	CT	Undertread Cementer			2
C H Dexter	Windsor Locks	CT		Toluene, Isopropyl Alcohol	50,000	12
CH Dexter Division	Windsor Locks	CT	Paper coating			2
Dexter Corp.	Windsor Locks	CT	Hemp TPY			2
Dexter Corp.	Windsor Locks	CT	Hemp TPY			2
Dexter Corp.	Windsor Locks	CT				2
Dexter Corp.	Windsor Locks	CT	Hemp Digester			2
E. I. duPont Chester Run Plant	New Castle	DE	R&D Fabric TNE			2
Celanese Fibers Co.	Rome	GA		Acetone	850	2
Alcoa Riverdale	Davenport	IA	Petroleum Storage		75,000	12
Alcoa Riverdale	Davenport	IA	Aluminum		13,150	1
Meredith Corporation	Des Moines	IA	Rotogravure			1
Winnabago Forest City	Forest City	IA	Surface Coating			17
A B Dick Co		IL	Coating		296,000	1
A B Dick Co	No	IL	Coater		20,000	3
A B Dick Co	Location	IL	Coater		20,000	3
A B Dick Co	Given	IL	Coater		20,000	3
A B Dick Co	By	IL	Coater		23,967	3
Abbott Laboratories Group Op Div	Illinois	IL	Valproic Acid Reactor		23,967	3
Amoco Chemicals Corp/Willow Sp Plant		IL	Polystyrene Process		1	3
Arnak Co. Chem. Div.		IL	Storage Tanks	Acrylonitrile	4	3

(Continued)

TABLE 1 (Continued)

COMPANY	CITY/COUNTY	ST	SOURCE	CHEMICAL	FLOW (CFM)	REF
Armak Co. Chem. Div.		IL	Storage Tank	Methyl Formcel		3
Dana Corp/Vator Gasket Div		IL	Mixers		14,550	3
Emulsicoat Inc		IL	Storage	Asphalt	25	3
Family Pride Center		IL	Dry Cleaning			3
Flair Cleaners		IL	Dry Cleaning			3
Flair Cleaners		IL	Dry Cleaning			3
Flair Cleaners		IL	Dry Cleaning			3
Flair Cleaners Inc.		IL	Dry Cleaning			3
Henkel Corp		IL	Storage	Chloroform		3
Henkel Corp		IL	Storage	Acrylonitrile		3
Hopkins Ag Chem/Atlanta Plant		IL	Chemical Manufacture		6,000	3
Ideal Uniform Rental Co		IL	Dry Cleaning			3
Knox Laundry & Dry Cleaner	No	IL	Dry Cleaning			3
Larkin Leather & Rubber Co.		IL	Spray Booth and Dryer		6,000	3
Larkin Leather & Rubber Co.	Location	IL	Spray booth		6,000	3
Lansing Cleaners		IL	Dry Cleaning			3
Lansing Cleaners	Given	IL	Dry Cleaning			3
Marsco Manufacturing Co.		IL	Spray Booth			3
Monarch Laundry Co.	By	IL	Tumble Dryers			3
Monarch Laundry Co.		IL	Tumble Dryers		11,256	3
Morton Norvich Chem/Ringwood Plant	Illinois	IL	Storage	Ammonium Thiocyanate		3
Morton Norvich Chem/Ringwood Plant		IL	Storage	Isopropanol		3
Morton Norvich Chem/Ringwood Plant		IL	Storage			3
Morton Norvich Chem/Ringwood Plant		IL	Storage	Methyl Ethyl Ketone		3
Morton Norvich Chem/Ringwood Plant		IL	Storage	Toluene		3
Morton Norvich Chem/Ringwood Plant		IL	Storage	Styrene		3
Morton Norvich Chem/Ringwood Plant		IL	Storage	Butyl Acrylate		3
Morton Norvich Chem/Ringwood Plant		IL	Storage	Methyl Chloride		3

(Continued)

TABLE 1 (Continued)

COMPANY	CITY/COUNTY	ST	SOURCE	CHEMICAL	FLOW (CFH)	REF
Morton Norwich Chem/Ringwood Plant		IL	Storage	Ethyl Acrylate		3
Morton Norwich Chem/Ringwood Plant		IL	Storage	Methyl Methacrylate		3
Morton Norwich Chem/Ringwood Plant		IL	Storage	Vinylidene Chloride		3
Morton Norwich Chem/Ringwood Plant		IL	Storage	Acrylonitrile		3
Morton Norwich Chem/Ringwood Plant		IL	Serfene Reactor		5	3
Morton Norwich Chem/Ringwood Plant		IL	Serfene Blend Tank			3
Morton Norwich Chem/Ringwood Plant		IL	Reactor			3
Morton Norwich Chem/Ringwood Plant		IL				3
Morton Norwich Chem/Ringwood Plant		IL	Storage			3
Morton Norwich Chem/Ringwood Plant		IL	Latex Reactor			3
Morton Norwich Chem/Ringwood Plant		IL	Storage			3
Morton Norwich Chem/Ringwood Plant	No	IL				3
Morton Norwich Chem/Ringwood Plant		IL	Storage	Methyl Acrylate		3
Morton Norwich Chem/Ringwood Plant	Location	IL	Chemical Manufacture			3
Morton Norwich Chem/Ringwood Plant		IL	Chemical Manufacture			3
Morton Norwich Chem/Ringwood Plant	Given	IL	Chemical Manufacture			3
Morton Norwich Chem/Ringwood Plant		IL	Storage	Methacrylic Acid		3
Morton Norwich Chem/Ringwood Plant	By	IL	Chemical Manufacture			3
Morton Norwich Chem/Ringwood Plant		IL				3
Morton Norwich Chem/Ringwood Plant	Illinois	IL	Storage (wastewater)			3
Morton Norwich Chem/Ringwood Plant		IL	Dryer			3
Morton Norwich Chem/Ringwood Plant		IL	Centrifuge			3
Morton Norwich Chem/Ringwood Plant		IL	Chemical Manufacture			3
Morton Norwich Chem/Ringwood Plant		IL	Dry Cleaning	Perchloroethylene		3
Mt. Greenwood Cleaners Inc.		IL				3
Hueller Company		IL				3
Odegarde Foundry & Cleaners Inc.		IL	Dry Cleaning			3
Olson Cleaners		IL	Dry Cleaning			3
One Hour Martinizing		IL	Dry Cleaning			3

(Continued)

TABLE 1 (Continued)

COMPANY	CITY/COUNTY	ST	SOURCE	CHEMICAL	REF	FLOW (CFM)
One Hour Martinizing		IL	Laundry Washing		3	
One Hour Martinizing		IL	Dry Cleaning		3	
Ozite Corp		IL	Rug Preheater		3	
Ozite Corp		IL	Latex Foam Oven		3	
Palatine Drive-In Cleaners Inc.		IL	Dry Cleaning		3	
Phoenix Closures		IL	Liquid Rubber Mixing		3	11,290
Plastic Capacitors Plant #3		IL	Paper Tube Roller		3	
Quincy Soybean Co.		IL	Extractor	Hexane	3	100
R. R. Donnelley & Sons Co.	Mo	IL	Rotogravure		3	192,000
R. R. Donnelley & Sons Co.	Location	IL			3	
R. R. Donnelley & Sons Co.	Given	IL	Rotogravure		3	192,000
R. R. Donnelley & Sons Co.	By	IL	Rotogravure		3	192,000
R. R. Donnelley & Sons Co.	Illinois	IL	Rotogravure		3	192,000
R. R. Donnelley & Sons Co.		IL	Reactor		3	
Staley Chemical		IL	Dry Cleaning		3	
Stinsons Laundry & Dry Cleaners		IL	Oil Storage		3	
Swift Edible Oil Co. Refining		IL	Oil Storage		3	
Swift Edible Oil Co. Refining		IL	Oil Storage		3	
Swift Edible Oil Co. Refining		IL	Oil Storage		3	
Swift Edible Oil Co. Refining		IL	Dry Cleaning	Perchloroethylene	3	
Tip Top Cleaners		IL	Dry Cleaning		3	
Town & County Cleaners		IL	Dry Cleaning		3	
Travenol Laboratories Inc		IL	Degreaser	Freon	3	1,000
Travenol Laboratories Inc		IL	Degreaser	Freon	3	1,000
Trim Cleaners		IL	Dry Cleaning		3	
Tuck Industries Inc.		IL	Coater	Heptane	3	15,200

(Continued)

TABLE 1 (Continued)

COMPANY	CITY/COUNTY	ST	SOURCE	CHEMICAL	FLOW (CFM)	REF
Tuck Industries Inc.		IL	Coater	Toluene	15,200	3
Tuck Industries Inc.		IL	Coater		15,200	3
Tuck Industries Inc.		IL	Solvent Recovery		11,750	3
Tuck Industries Inc.		IL	Solvent Recovery		25,600	3
Tuck Industries Inc.		IL	Coater		25,600	3
Turco Products Div		IL	Chemical Blending Tanks		800	3
U.S. Industrial Chemicals		IL	Sulfuric Acid Production			3
V. J. Dolan & Co. Inc.		IL	Mix Tanks		2,000	3
V. J. Dolan & Co. Inc.		IL	Sand Mills		2,000	3
V. J. Dolan & Co. Inc.	No	IL	Mix Tanks		2,000	3
V. J. Dolan & Co. Inc.		IL	Filling Station		2,000	3
V. J. Dolan & Co. Inc.	Location	IL	Mixers and Tanks		2,000	3
V. J. Dolan & Co. Inc.		IL	Holding Tanks		2,000	3
V. J. Dolan & Co. Inc.	Given	IL	Filling Station		2,000	3
V. J. Dolan & Co. Inc.		IL	Heating Kettles		2,000	3
V. J. Dolan & Co. Inc.	By	IL	Wheat Germ Extraction	Hexane	4,000	3
VioBin Corp		IL	Solvent Extraction	Ethylene Dichloride	1,500	3
VioBin Corp		IL	Desolventizer Tissue Plant	Ethylene Dichloride	2,000	3
VioBin Corp	Illinois	IL	Cooker			3
VioBin Corp		IL	Cooker			3
VioBin Corp		IL	Fat Kettle			3
VioBin Corp		IL	Accumulator			3
VioBin Corp		IL				3
VR/Wesson		IL	Curing Oven		800	3
Warner Lambert		IL	Coating (stencil)			3
Weber Marking Systems Inc.		IL	Spray Booth		650	3
Western Electric Co Inc		IL	Soldering			3
Western Electric Co Montgomery Plant		IL	Rotogravure		8,200	3
World Color Press						3

(Continued)

TABLE 1 (Continued)

COMPANY	CITY/COUNTY	ST	SOURCE	CHEMICAL	FLOW (CFM)	REF
World Color Press		IL	Rotogravure		8,200	3
World Color Press		IL	Rotogravure		8,200	3
World Color Press	No	IL	Rotogravure		8,200	3
World Color Press	Location	IL	Rotogravure		8,200	3
World Color Press	Given	IL	Rotogravure		70,000	3
World Color Press	By	IL	Press		70,000	3
World Color Press	Illinois	IL	Press		70,000	3
World Color Press		IL	Rotogravure		70,000	3
World Color Press		IL	Rotogravure		70,000	3
World Color Press		IL	Rotogravure		70,000	3
Shell Oil Co.	Bedford Park	IL				10
Amoco	Berwyn	IL				10
Chicago Rotoprint	Chicago	IL	Rotogravure		20,000	13
Phillips Petroleum Co.	Decatur	IL				10
Amoco	Des Plaines	IL				10
Cities Service Co.	Des Plaines	IL				10
Shell Oil Co.	Des Plaines	IL				10
Union Oil	Des Plaines	IL				10
Energy Cooperative Inc.	East Chicago	IL				10
Phillips Petroleum Co.	East Chicago	IL				10
Phillips Petroleum Co.	East St. Louis	IL				10
Phillips Petroleum Co.	Kankakee	IL				10
Union Oil	Lemont	IL				10
Deere Planter Works	Moline	IL	Surface Coating			1
Reichhold Chemical Inc	Morris	IL	Maleic Anhydride Catalytic Reactor	Benzene	43,000	3, 24
F.ble Printing Co.	Mt. Morris	IL		Toluene, Xylene	120,000	12
World Color Press	Salem	IL	Rotogravure		70,000	13
World Color Press	Salem	IL	Rotogravure		140,000	13

(Continued)

TABLE 1 (Continued)

COMPANY	CITY/COUNTY	ST	SOURCE	CHEMICAL	FLOW (CFM)	REF
Kerr-McGhee	Clairmont	IN	Petroleum Storage/Handling			4
Phillips Petroleum	Clairmont	IN	Petroleum Storage/Handling			4
Sun Oil Co	Clairmont	IN	Petroleum Storage/Handling			4
Triangle	Clairmont	IN	Petroleum Storage/Handling			4
Sunmark Industries	Clermont	IN				10
ARA Cleaners and Alterations	East Chicago	IN	Dry Cleaning	Perchloroethylene		1
ECL	East Chicago	IN	Petroleum Storage/Handling			4
N4 Method Cleaners	East Chicago	IN	Printing			3
Silver Cleaners	East Chicago	IN	Dry Cleaning	Perchloroethylene		1
Rexham Corp	Edinburg	IN				4
Riegel Paper Corp.	Edinburg	IN		Toluene, Ethyl Acetate	10,000	12
Hiles Laboratories	Elkhart	IN			11,000	12
Phillips Petroleum	Indianapolis	IN				10
Triangle Refineries	Indianapolis	IN				10
Western Electric Co	Indianapolis	IN	Surface Coating			1
Western Electric Co	Indianapolis	IN	Surface Coating			1
Farm Bureau	Jolietville	IN	Petroleum Handling/Storage			4
R. R. Donnelley	Mattson	IN	Rotogravure		160,000	13
R. R. Donnelley	Warsaw	IN	Rotogravure			4
R. R. Donnelley	Warsaw	IN	Rotogravure		375,000	13
Indiana Farm Bureau	Westfield	IN	Rotogravure			10
General Electric Co	Allen Co.	KY	Organic Solvent		5,509	1
Brown Printing Co.	Bowling Green	KY				17
Holley Carburetor Div	Bowling Green	KY	Degreasing	Trichloroethylene	2,507	1
Crown Zellerbach Corp.	Florence	KY	Paper coating		28,286	1
Crown Zellerbach Corp.	Florence	KY	Surface Coating		28,286	1
Crown Zellerbach Corp.	Florence	KY		Toluene, Methanol	30,000	12
Swedcost, Inc	Florence	KY	Plastics Production			1

(Continued)

TABLE 1 (Continued)

COMPANY	CITY/COUNTY	ST	SOURCE	CHEMICAL	FLOW (CFM)	REF
Swedcost, Inc.	Florence	KY	Plastics Production		176	1
CANCO Chemical Co	Fort Thomas	KY	Polypropylene Production		8,087	1
DuPont	Greenup Co	KY	Plastics Production	Freon 11 and 114 ABS	7,592	1
IBH	Lexington	KY	Surface Coating		10,982	1
IBH	Lexington	KY	Surface Coating		11,406	1
Continental Forest Ind	Louisville	KY	Printing		9,993	1
Fawcett Printing Corp.	Louisville	KY	Rotogravure	Toluene, Xylene, Naphtha aliphatics, et al	108,000	12
Spalding Laundry	Louisville	KY	Dry Cleaning	Perchloroethylene		1
Spalding Laundry	Louisville	KY	Dry Cleaning	Perchloroethylene		1
Standard Gravure Corp.	Louisville	KY	Rotogravure	C6-C7	240,000	17, 25
Swiss Cleaners & Laundry	Louisville	KY	Dry Cleaning	Perchloroethylene		1
Borg-Warner	Madisonville	KY	Degreasing		3,107	1
DuPont	Wirtland	KY		"Freon"	8,000	12
Hooker Chemicals	Hahnville	LA	Reprocessed Chlorinated Hydrocarbons		227	5
Murphy Oil Co.	Meroux	LA			12.4	10
Georgia Pacific Corporation	Plaquemine	LA	Chemical Manufacture	Cumene Cumene Hydroperoxide		5
Clearwater Fabric	Boston	MA	Dry Cleaning	Perchloroethylene		1
Scott Graphics	Holyoke	MA		Toluene, Ketones, Alcohols	15,000	12
House of David	Lynn	MA	Dry Cleaning	Perchloroethylene	340	1
Whyte Enterprise	Lynn	MA	Dry Cleaning	Perchloroethylene		1
Lawson Coin Wash	Natick	MA	Dry Cleaning	Perchloroethylene		1
Holly Cleaners	Newton	MA	Dry Cleaning	Perchloroethylene		1
Whiting and Davis	Plainville	MA	Degreasing	Perchloroethylene	625	1
Marquis Cleaners	Salem	MA	Dry Cleaning	Perchloroethylene		1
Salem Laundry	Salem	MA	Dry Cleaning	Perchloroethylene		1
Laundrite Uniforms	Wakefield	MA	Dry Cleaning	Perchloroethylene		1

(Continued)

TABLE 1 (Continued)

COMPANY	CITY/COUNTY	ST	SOURCE	CHEMICAL	FLOW (CFM)	REF
J L Thompson Rivet Corp	Waltham	MA	Degreasing	Trichloroethylene		1
J L Thompson Rivet Corp	Waltham	MA	Degreasing	Trichloroethylene		1
Polaroid	Waltham	MA	Photographic Film Coating	Mixed Ketones	6,000	22
Celanese	Cumberland	MD		Acetone	112,500	12
B. P. Oil Co.	Finksburgh	MD				10
Dow Chemical	Midland	MI	Chlorobenzene Manufacture	Benzene and monochlorobenzene		6
Dow Chemical	Midland	MI	Chlorobenzene Manufacture	Paradichlorobenzene		6
Standard Oil of Ohio	Taylor	MI				10
General Motors	Warren	MI			500	12
Ford Motor Co.	Wayne	MI		Xylene, Butanol, Cellosolve, Methyl Ethyl Ketone	20,000	12
Ford Motor Co.	Wayne	MI	Automotive Top Coat Spray			22
Anderson Corporation	Bayport	MN	Surface Coating		6,000	1
Anderson Corporation	Bayport	MN	Surface Coating		3,000	1
Anderson Corporation	Bayport	MN	Surface Coating		1300	1
Anderson Corporation	Bayport	MN	Surface Coating		950	1
Thermo King Corp	Minneapolis	MN	Surface Coating			1
Thermo King Corp	Minneapolis	MN	Degreasing	1,1,1-trichloroethane	42	1
Thermo King Corp	Minneapolis	MN	Degreasing			14
Shell Oil Co.	Minneapolis	MN	Surface Coating	Toluene	42	1
Williams Pipeline Co.	St. Paul	MN				10
J. D. Streett	St. Charles	MO				10
Texasco Inc.	St. Louis	MO				10
Triangle Refinery	St. Louis	MO				10
W. F. Hall	St. Louis	MO				10
Morton Corporation	Corynth	MS	Rotogravure		65,000	13
Lorillard Greensboro Plt	Clover	NC		Toluene, VM&P Naphtha	25,000	12
Lorillard Greensboro Plt	Greensboro	NC	Cigarette manufacture		3,545	1
Lorillard Greensboro Plt	Greensboro	NC	Cigarette manufacture	CCl ₄	3,545	1

(Continued)

TABLE 1 (Continued)

COMPANY	CITY/COUNTY	ST	SOURCE	CHEMICAL	FLOW (CFH)	REF
Shuford Mills	Hickory	NC	Tape Manufacture			21
Hercofina	New Hanover Co.	NC	Chemical Manufacture	p-Xylene	24,530	1
Hercofina	New Hanover Co.	NC	Industrial Process	"Armtc mthyl"	24,530	1
Hercofina	New Hanover Co.	NC	Chemical Manufacture	p-Xylene	24,530	1
Hercofina	New Hanover Co.	NC	Industrial Process	Aromatic Methyl Ester		1
Hercofina	New Hanover Co.	NC	Chemical Manufacture	"Reactor armic ad, mth"	24,500	1
Hercofina	New Hanover Co.	NC	Chemical Manufacture	"Reactor armic ad, mth"	24,500	1
Hercofina	Wilmington	NC	Dimethyl Terephthalate Manufacture	p-Xylene and other HC's	42,000	19
Phillips Petroleum	Carteret	NJ				10
Reichhold Chemical	Elizabeth	NJ	Maleic Anhydride Manufacture	Benzene	27,000	1
				Maleic Anhydride		
Ottex Inc	Fairfield	NJ	Textile Products		800	1
Phillips Petroleum	Gloucester	NJ				10
Phillips Fuel Co.	Hackensack	NJ				10
Western Electric Co	Kearny	NJ			700	1
Celanese Plastics	Newark	NJ	Plastics Production		12,611	1
Celanese Plastics	Newark	NJ	Plastics Production		7,211	1
Celanese Plastics	Newark	NJ	Plastics Production		13,100	1
Celanese Plastics	Newark	NJ	Plastics Production		12,351	1
Celanese Plastics	Newark	NJ	Plastics Production		10,000	1
Sunmark Industries	Newark	NJ				10
Burroughs Corp.	Park Ridge	NJ				
Combintex Corp	Passaic	NJ	Dry Cleaning	Methyl ethyl ketone, Toluene	6,000	12
Combintex Corp	Passaic	NJ	Dry Cleaning	Perchloroethylene	530	1
MU-Method Dyeing and Proc	Union City	NJ	Degreasing	Perchloroethylene	530	1
MU-Method Dyeing and Proc	Union City	NJ	Degreasing	Perchloroethylene	1500	1
Chevron Oil	Albuquerque	NM		Perchloroethylene	1500	1
Continental Oil	Albuquerque	NM				10

(Continued)

TABLE 1 (Continued)

COMPANY	CITY/COUNTY	ST	SOURCE	CHEMICAL	FLOW (CFM)	REF
Shell Oil Co.	Sparks	NV				10
Kallmorgen Corp Photocircuits	Aquebogue	NY	Solvent Stripping	Aliphatic Cl Compd	2,000	1,20
Tuck Industries Inc.	Beacon	NY	Roller coating machines	Toluene	10,952	20
Tuck Industries Inc.	Beacon	NY	Roller coating machines	Toluene	10,952	20
Tuck Industries Inc.	Beacon	NY	Roller coating machines	Toluene	10,952	20
GAF Corp	Binghamton	NY		Methyl chloride	6,900	1, 20
				Methyl alcohol		
GAF Corp	Binghamton	NY	Chem specialty pilot plant	Hydrogen Chloride	16,000	1, 20
GAF Corp.	Binghamton	NY		Methyl chloride,	5,150	20
				other aliphatic chlorides		
M. Wile and Co.	Buffalo	NY	Dry cleaning	Perchloroethylene	400	1, 20
M. Wile and Co.	Buffalo	NY	Dry cleaning	Perchloroethylene	400	1, 20
Trico Products Corp.	Buffalo	NY	Degreasing	Trichloroethylene	3,300	1, 20
Labelon-Hopevell Pl	Canandaigua	NY		Dimethyl Ketone	9,000	1,20
Labelon-Hopevell Pl	Canandaigua	NY	Paper Coating	Toluene, Methyl Ethyl Ketone,	1,750	20
				Dimethyl Ketone, Ethanol,		
				Acetates, Others		
F. N. Burt	Cheektowaga	NY	Solvent coating	Toluene	3,800	20
Nashua Industrial Tape Div.	Colonie	NY	Tape Coater	Toluene, Nonmethane alkane	17,500	20
Nashua Industrial Tape Div.	Colonie	NY	Tape Coater	Toluene, Nonmethane alkane		20
Nashua Industrial Tape Div.	Colonie	NY	Tape Coater	Toluene, Nonmethane alkane	17,500	20
Nashua Industrial Tape Div.	Colonie	NY	Tape Coater	Toluene, Nonmethane alkane		20
Nashua Industrial Tape Div.	Colonie	NY	Tape Coater	Toluene, Nonmethane alkane	17,500	20
Nashua Industrial Tape Div.	Colonie	NY	Tape Coater	Toluene, Nonmethane alkane		20
Arcata Graphics BFLO	Depeu	NY		Toluene, xylene,	20,000	20
				misc. organics,		
				Naphthalene		

(Continued)

TABLE 1 (Continued)

COMPANY	CITY/COUNTY	ST	SOURCE	CHEMICAL	FLOW (CFM)	REF
Arcata Graphics BFLO	Depew	NY		Toluene, xylene, misc. organics, naphthalene	20,000	20
Arcata Graphics BFLO	Depew	NY		Toluene, Xylene	50,000	20
Arcata Graphics BFLO	Depew	NY		Misc. Organics, Naphthalene	50,000	20
Arcata Graphics BFLO	Depew	NY		Toluene, Xylene, Misc. Organics, Naphthalene	50,000	20
Arcata Graphics BFLO	Depew	NY		Toluene, Xylene, Misc. Organics, Naphthalene	50,000	20
Arcata Graphics BFLO	Depew	NY		Toluene, Xylene, Misc. Organics, Naphthalene	20,000	20
Carrier Air Cond. Corp.	Devitt	NY	Degreaser	Naphthalene	5,500	1,20
Carrier Air Cond. Corp.	Devitt	NY	Degreaser	Trichloroethylene	3,230	1,20
E. Fishkill Facility	Dutchess Co.	NY	Vapor Degreasing	Trichloroethylene	6,200	1
E. Fishkill Facility	East Fishkill	NY	Degreasing	Perchloroethylene	8,260	20
Endicott Lab	Endicott	NY	Developer	Other acetates	800	1
Endicott Lab	Endicott	NY			3,600	1
Endicott Lab	Endicott	NY	Developer		500	1
Endicott Lab	Endicott	NY			1,200	1
Endicott Lab	Endicott	NY			3,910	1
Endicott Lab	Endicott	NY			1,250	1
Endicott Lab	Endicott	NY	Degreaser		1,600	1
Endicott Lab	Endicott	NY	Degreaser		3,730	1

(Continued)

TABLE 1 (Continued)

COMPANY	CITY/COUNTY	ST	SOURCE	CHEMICAL	FLOW (CFM)	REF
Endicott Lab	Endicott	NY			2,730	1
Endicott Lab	Endicott	NY	Developer		3,000	1
Endicott Lab	Endicott	NY			600	1
Endicott Labs	Endicott	NY	Spray Degreasing		1,250	1
IBM Corp.	Endicott	NY	Developer	Trichloroethylene	800	20
IBM Corp.	Endicott	NY		Methyl Chloride	3,600	20
IBM Corp.	Endicott	NY	Developer	Chloroform	500	20
IBM Corp.	Endicott	NY		Trichloroethane	600	20
IBM Corp.	Endicott	NY		Aliphatic Halogens	1,200	20
IBM Corp.	Endicott	NY	Degreaser	Perchloroethylene	8,670	20
IBM Corp.	Endicott	NY	Tinners	Perchloroethylene, IPA		20
IBM Corp.	Endicott	NY		Perchloroethylene, IPA		20
IBM Corp.	Endicott	NY		Trichloroethane	1,000	20
IBM Corp.	Endicott	NY		Aliphatic chloride compound	1,700	20
IBM Corp.	Endicott	NY	Tinner	Perchloroethylene, IPA	3,010	20
IBM Corp.	Endicott	NY	Wave Solder	Perchloroethylene, IPA		20
IBM Corp.	Endicott	NY		Perchloroethylene, IPA		20
IBM Corp.	Endicott	NY	Vapor Degreasing	Perchloroethylene, IPA	12,650	20
IBM Corp.	Endicott	NY	Tinners	Perchloroethylene, IPA		20
IBM Corp.	Endicott	NY	Tinners	Perchloroethylene, IPA		20
IBM Corp.	Endicott	NY	Tinner exhausts	Perchloroethylene, IPA		20
IBM Corp.	Endicott	NY	Wave solder machines	Perchloroethylene, IPA	5,110	20
IBM Corp.	Endicott	NY		Perchloroethylene, IPA		20
IBM Corp.	Endicott	NY		Methyl chloride	1,250	20
IBM Corp.	Endicott	NY		Chloroform	1,250	20
IBM Corp.	Endicott	NY	Spray Degreasing	Trichloroethylene	1,600	20
IBM Corp.	Endicott	NY	Degreaser	Aliphatic Chloride Compound	2,730	20

(Continued)

TABLE 1 (Continued)

COMPANY	CITY/COUNTY	ST	SOURCE	CHEMICAL	FLOW (CFM)	REF
IBM Corp.	Endicott	NY	Developer	Trichloroethane	3,000	20
Hygrade Metal Mldg Mfg Corp	Farmingdale	NY		Perchloroethylene	3,200	1,20
Endo Laboratories	Garden City	NY	Film Coating	Methylene Chloride, IPA	500	1,20
Elmgrove Plant	Gates	NY	Degreasing	Trichloroethylene	1,700	1,20
Photocircuits	Glen Cove	NY	Solvent Stripping	Chlorinated Aliphatic	2,000	1,20
Photocircuits	Glen Cove	NY	Curing Oven		4,700	20
Kodak Park Div.	Greene	NY	Drying and Curing	Dimethyl Ketone, Methanol, Ethanol, Isopropanol, Aliphatic alcohol, aliphatic Cl compd, methyl ethyl ketone, aliphatic ketones	18,000	20
Kodak Park Div.	Greene	NY	Costing Drying and Curing	Dimethyl Ketone, Methanol, Aliphatics	40,000	20
Kodak Park Div.	Greene	NY		Aliph Cl compound, Methanol, Dimethyl Ketone, Naphthenes, Aliphatic Alcohol	3,000	20
Kodak Park Div.	Greene	NY		Nonmethane alkane, Toluene, Methanol, Ethanol, Dimethyl Ketone, Methyl Ethyl Ketone	12,000	20

(Continued)

TABLE 1 (Continued)

COMPANY	CITY/COUNTY	ST	SOURCE	CHEMICAL	FLOW (CFM)	REF
Kodak Park Div.	Greene	NY	Film Coating	Diethyl Ketone,	26,000	20
				Aliphat. Cl compd,		
				Methanol, Toluene,		
				MEK, Trichloroethane,		
				MIBK, Cyanide Comp NEC,		
Kodak Park Div.	Greene	NY	Film Coating	Chloroform, Ethanol,	26,000	20
				Alipha Ethers		
				Diethyl Ketone,		
				Aliphatic Cl compd,		
				Methanol, Toluene,		
Vic Industries Corp	Harnell	NY	Degreaser	MEK, Trichloroethane,	3,000	20
				MIBK, Cyanide compd,		
				Chloroform, Ethanol,		
				Aliphatic Ethers		
				Trichloroethylene		
				Benzene, Aromatic N Capds		
				Benzene, Aromatic N Capds		
				Benzene, Aromatic N Capds		
				Benzene, Aromatic N Capds		
				Benzene, Aromatic N Capds		
				Benzene, Aromatic N Capds		
				Benzene, Aromatic N Capds		
				Benzene, Aromatic N Capds		
				Benzene, Aromatic N Capds		
				Benzene, Aromatic N Capds		
Hilard Chemical Corp	Hauptpauge	NY	Spray Dryer	Aliphatic Cl Compd	750	20
				Perchloroethylene		
				Perchloroethylene		
				Misc. organics		
				Isopropyl Alcohol		
Universal Instruments Corp.	Kirtwood	NY	Solvent degreaser; wave solder machine		2,840	20

(Continued)

TABLE 1 (Continued)

COMPANY	CITY/COUNTY	ST	SOURCE	CHEMICAL	FLOW (CFH)	REF
GM Harrison Radiator Div.	Lockport	NY	Vapor Degreaser	Trichloroethylene	658	1, 20
GM Harrison Radiator Div.	Lockport	NY	Vapor Degreaser	Perchloroethylene	3,000	20
GM Harrison Radiator Div.	Lockport	NY	Vapor Degreaser	Trichloroethylene	3,000	20
Harrison Radiator Div.	Lockport	NY	Vapor Degreasing	Trichloroethylene	2,940	20
Harrison Radiator Div.	Lockport	NY	Vapor Degreasing	Trichloroethylene	2,940	20
Harrison Radiator Div.	Lockport	NY	Vapor Degreaser	Trichloroethylene	2,940	20
New York News Inc.	Long Island	NY	Rotogravure	Xylol, VM&P Naphtha,	6,500	17
AMF Inc.	Lowville	NY		Cellusolve		12
Technical Tape	New Rochelle	NY		Toluene, Heptane	85,000	12
Stauffer	Newburgh	NY	Coating	MEK, MIBK	16,000	1,20
Stauffer	Newburgh	NY	Coating	MEK, MIBK	16,000	1,20
Stauffer	Newburgh	NY	Coating	Toluene, Acetates	11,000	20
Hooker Chemical Corp.	Niagara Falls	NY	Chemical Manufacture	Toluene	166	20
Sunmark Industries	Oceanside	NY				10
IBM Corp	Owego	NY	Solder Cleaning	Trichloroethane	855	1,20
IBM Corp	Owego	NY	Spray Brush Scrubber	Aliphatic Cl Compd	1700	1,20
Garlock Inc.	Palmyra	NY	Sheeter	Nonmethane alkanes	11,000	1,20
Garlock Inc.	Palmyra	NY	Sheeter	Nonmethane alkanes	11,000	1,20
Garlock Inc.	Palmyra	NY	Sheeter	Nonmethane alkanes	11,000	1,20
Materials Research Corp	Pearl River	NY	Ceramic Slurry Drying	Trichloroethane, Ethanol	17,700	1,20
IBM Corp	Poughkeepsie	NY	Circuit Board Etching		3,000	1
IBM Corp	Poughkeepsie	NY	Circuit Board Stripping		3,000	1
Eastman Kodak	Rochester	NY		Methylene chloride and others	40,000	12
GM Rochester Products Div.	Rochester	NY	Carburetor Test Manifold		4,000	20
GM Rochester Products Div.	Rochester	NY	Carburetor Test Manifold		4,000	20
GM Rochester Products Div.	Rochester	NY	Carburetor Test Vacuum Manifold		4,000	20

(Continued)

TABLE 1 (Continued)

COMPANY	CITY/COUNTY	ST	SOURCE	CHEMICAL	FLOW (CFM)	REF
GM Rochester Products Div.	Rochester	NY	Carburetor Test Vacuum Manifold	Aliphatic Alcohols and Aldehydes	4,000	20
GM Rochester Products Div.	Rochester	NY	Carburetor Test Vacuum Exhaust		4,000	20
GM Rochester Products Div.	Rochester	NY	Carburetor Test Vacuum Exhaust		4,000	20
GM Rochester Products Div.	Rochester	NY	Vapor Degreaser	Trichloroethylene	800	1,20
GM Rochester Products Div.	Rochester	NY	Vapor Degreaser	Trichloroethylene	800	1,20
GM Rochester Products Div.	Rochester	NY	Vapor Degreaser	Trichloroethylene	800	1,20
GM Rochester Products Div.	Rochester	NY	Degreasing	Trichloroethylene	800	1,20
GM Rochester Products Div.	Rochester	NY	Vapor Degreasing	Trichloroethylene	1700	1,20
GM Rochester Products Div.	Rochester	NY	Vapor Degreasing	Trichloroethylene	1700	1,20
GM Rochester Products Div.	Rochester	NY	Vapor Degreasing	Trichloroethylene	1700	1,20
GM Rochester Products Div.	Rochester	NY	Vapor Degreasing	Trichloroethylene	800	1,20
GM Rochester Products Div.	Rochester	NY	Vapor Degreasing	Trichloroethylene	2,200	1,20
Hawk-Eye Plant	Rochester	NY	Degreaser	Trichloroethylene	12,914	20
Hawk-Eye Plant	Rochester	NY	Testing Hoods	Aliphatic Halogenated HC		
Hawk-Eye Plant	Rochester	NY	Cleaning and Cementing	Acetone, MEK		20
Kodak Park Div.	Rochester	NY	Film Coating		26,000	1
Kodak Park Div.	Rochester	NY	Film Coating		26,000	1
Kodak Park Div.	Rochester	NY	Film Coating		12,000	1
Stromberg Carlson	Rochester	NY	Vapor Degreaser	Methylene Chloride	1,800	1,20
General Electric Co.	Salina	NY	Vapor Degreaser	Trichloroethylene	1,839	1,20
Texas East Transmission Corp.	Selkirk	NY	Truck loading	Aromatic N Compound		
Texas East Transmission Corp.	Selkirk	NY	Rail car loading	Ethyl Mercaptan, Propane	179	1,20
GTE Sylvania Inc	Seneca Falls	NY	Degreaser	Ethyl Mercaptan, Propane	179	1,20
Oneida Silversmiths	Sherrill	NY	Degreasing	Trichloroethylene	2,280	1,20
Bristol Myers	Syracuse	NY	Antibiotics Manufacture	Trichloroethylene	1,085	1,20
Bristol Myers	Syracuse	NY	Antibiotics Manufacture	HIBK, Acetone	6,350	1,12,20
Orica Industries Limited	Syracuse	NY	Extraction Pilot Plant	HIBK, Acetone		12,20
	Syracuse	NY	Extraction Pilot Plant	Aliphatic Cl Compd	5	1,20

(Continued)

TABLE 1 (Continued)

COMPANY	CITY/COUNTY	ST	SOURCE	CHEMICAL	FLOW (CFH)	REF
Otisca Industries Limited	Syracuse	NY				
RE Dietz	Syracuse	NY	Vapor Degreaser,	Aliphatic Cl Campd	1,440	20
Booth Oil Co. Inc.	Tonawanda	NY	Oil Demulsification	Trichloroethylene	11	20
Behr-Manning Company	Troy	NY		Toluene	20,000	12
Behr-Manning Company	Troy	NY		Toluene	40,000	12
Xerox	Webster	NY	Spray Dryer	Chloroform	1,350	1,20
Xerox	Webster	NY	Metal Coating	Methyl Ethyl Ketone	600	1,20
Xerox	Webster	NY	Spray Dryer	Chloroform		20
Xerox	Webster	NY	Circuit Board Cleaning	Chloroform		20
Xerox	Webster	NY	Spray Dryer	Chloroform		20
Xerox	Webster	NY	Spray Dryer	Chloroform		20
Xerox	Webster	NY	Spray Dryer	Chloroform		20
Xerox	Webster	NY	Spray Dryer	Chloroform, Misc. Organics		20
Xerox	Webster	NY	Spray Dryer	Chloroform		20
Standard Oil of Ohio	Akron	OH				12
Sunmark Industries	Akron	OH				10
Shell Chemical Co.	Bel Pre	OH			10,000	12
Cities Service Co.	Brecksville	OH				10
Standard Oil of Ohio	Canton	OH				10
Standard Oil of Ohio	Cincinnati	OH				10
Standard Oil of Ohio	Cleveland	OH				10
Standard Oil of Ohio	Cleveland	OH				10
Sunmark Industries	Cleveland	OH				10
Union Oil	Columbus	OH				10
Phillips Petroleum	Columbus	OH				10
Shell Oil Co	Columbus	OH				10
Standard Oil of Ohio	Columbus	OH				10
Sunmark Industries	Columbus	OH				10
Union Oil	Columbus	OH				10
Dayton Press	Dayton	OH	Rotogravure		64,000	13

(Continued)

TABLE 1 (Continued)

COMPANY	CITY/COUNTY	ST	SOURCE	CHEMICAL	FLOW (CFM)	REF
Dayton Press Inc.	Dayton	OH	Gravure		36,320	7
Inland Div Plant 1	Dayton	OH	Vapor Finishing		2,000	7
Inland Div Plant 2	Dayton	OH	Coater and Oven		70,000	7
Inland Div Plant 2	Dayton	OH	Coater and Oven		70,000	7
Inland Manufacturing Company	Dayton	OH		Xylene	75,000	12
Inland Manufacturing, General Motors	Dayton	OH		Xylene	100,000	12
Shell Oil Co.	Dayton	OH				10
Standard Oil of Ohio	Dayton	OH				10
Sunmark Industries	Dayton	OH				10
Union Oil	Dayton	OH				10
Moore Business Forms	Fremont	OH			25,000	12
Marathon Oil Co.	Lebanon	OH				10
Shell Oil Co.	Lima	OH				10
Standard Oil of Ohio	Lima	OH				10
Standard Oil of Ohio	Lorain	OH				10
Textile Leather Div of Gen Tire/Rubber	Lucas Co.	OH	Printing/Finishing			1,7
Laminated & Coated Products Div	Miami Co.	OH	Surface Coating		22,000	1
Inland Division	Montgomery Co.	OH	Motor Vehicle Parts		2,000	1,7
Inland Division	Montgomery Co.	OH	Surface coating		70,000	1
Inland Division	Montgomery Co.	OH	Surface Coating		70,000	1
Inland Division	Montgomery Co.	OH	Surface Coating		70,000	1
Inland Division	Montgomery Co.	OH	Surface Coating		70,000	1
Standard Oil of Ohio	Niles	OH				10
Fasson Tech Center	Painesville	OH	Coaters and Dryers		48,000	7
Fasson Tech Center	Painesville	OH	Coaters and Dryers		50,000	7
Standard Oil of Ohio	Sciotoville	OH				10
Springfield Gravure Corp.	Springfield	OH	Rotogravure		39,000	7
PPG Industries/Barberton Plant	Summit Co.	OH	Resins Manufacturing		5,400	1,7

(Continued)

TABLE 1 (Continued)

COMPANY	CITY/COUNTY	ST	SOURCE	CHEMICAL	FLOW (CFM)	REF
Union Oil	Talmadge	OH				10
Standard Oil of Ohio	Tiffin	OH				10
Standard Oil of Ohio	Todhunter	OH				10
Cities Service Co.	Toledo	OH				10
General Tire & Rubber Co.	Toledo	OH		Methyl Ethyl Ketone		34
Shell Oil Co.	Toledo	OH				10
Standard Oil of Ohio	Toledo	OH				10
Sunmark Industries	Toledo	OH				10
Union Oil	Toledo	OH				10
Brown-Bridge Mills Inc.	Troy	OH		Toluene, Methanol	20,000	12
Inmont Automotive	Whitehouse	OH	Spray Drying		400	7
Fasson Div of Avery	Bucks Co.	PA	Surface Coating		87,075	1
Fasson Div of Avery	Bucks Co.	PA	Surface Coating		47,170	1
Diversified Printing Corproure	Chester Co.	PA	Gravure		30,000	1
Diversified Printing Corproure	Chester Co.	PA	Gravure		21,000	1
Diversified Printing Corproure	Chester Co.	PA	Gravure		21,000	1
Diversified Printing Corproure	Chester Co.	PA	Gravure		30,000	1
Woolrich, Inc.	Clinton Co.	PA	Dry Cleaning		70	1
Avtex Fibers Inc	Crawford Co.	PA	Surface Coating	Acetone	80,379	1
American Can Company	Cumberland Co.	PA	Surface Coating		6,880	1
FNC Corp	Delaware Co.	PA	Surface Coating		93,426	1
Sun Oil of PA	Delaware Co.	PA	Petroleum, fugitive HC emissions		67	1
Armstrong Cork	Lancaster	PA	Degreasing	Benzene	10,000	12
Aluminum Co	Lancaster Co.	PA	Plastics Production	Xylene	1,500	1
Armstrong Cork	Lancaster Co.	PA	Plastics Production			1
Armstrong Cork	Lancaster Co.	PA	Plastics Production			1
Std Coated Prod	Luzerne Co	PA	Textiles-Blending Area		25,000	1
Std Coated Prod	Luzerne Co.	PA	Gravure		25,000	1

(Continued)

TABLE 1 (Continued)

COMPANY	CITY/COUNTY	ST	SOURCE	CHEMICAL	FLOW (CFH)	REF
Std Coated Prod	Luzerne Co.	PA	Laminator		25,000	1
Std Coated Prod	Luzerne Co.	PA	Gravure (textiles)		18,600	1
Alco Corp	Philadelphia	PA	Fabricated rubber loading & storage			1
Aldon Rubber Co.	Philadelphia	PA	Surface coating		14,000	1
Allied Chemical	Philadelphia	PA	Phenol Production		10,000	1
Allied Chemical	Philadelphia	PA	Phenol Oxidizer		10,000	1
Allied Chemical	Philadelphia	PA	Phenol oxidizer		5,540	1
Allied Chemical	Philadelphia	PA	Phenol		5,540	1
Allied Chemical	Philadelphia	PA	Phenol oxidizer		10,770	1
Allied Chemical	Philadelphia	PA	Phenol		10,770	1
Sunmark Industries	Twin Oaks	PA				10
Sunmark Industries	Willow Grove	PA				10
Adhesives Research Inc.	York Co.	PA	Coating Oven		6,000	1
Adhesives Research Inc.	York Co.	PA	Coating Oven		12,000	1
Adhesives Research Inc.	York Co.	PA	Coating Oven		3,000	1
Adhesives Research Inc.	York Co.	PA	Pesticides		3,000	1
Agvay Inc	York Co.	PA	Pesticide Packaging		6,000	1
Agvay Inc.	York Co.	PA	Pesticide Preparation		4,000	1
Roche	Manati Co.	PR	Pharmaceutical Preparation	Fluorazepam HCl	9,223	1
Union Carbide	Ponce	PR	Organic Chemical		10,650	1
Mobil Oil	East Providence	RI	Asphalt Blending			1
Lebanon Knitting	Pawtucket	RI	Dry Cleaning	Perchloroethylene		1
Clvind Twist	Providence	RI	Degreasing	"Safety Solvent"	300	1
IMP Knife	Providence	RI	Degreasing	Trichloroethylene		1
IMP Knife	Providence	RI	Degreasing	Trichloroethylene		1
Prov Gravure	Providence	RI	Gravure	Toluene		1
Prov Gravure	Providence	RI	Gravure	"Lactol"		1
Prov Gravure	Providence	RI		Toluene		1

(Continued)

TABLE 1 (Continued)

COMPANY	CITY/COUNTY	ST	SOURCE	CHEMICAL	FLOW (CFM)	REF
Prov Gravure	Providence	RI	Gravure	"Lactol"		1
Charleston Rubber Co.	Charleston	SC		Naphtha and Naphthal Spirits	10,000	12
Morton Co. Safety Products Div	Charleston	SC	Fabricated Rubber (glove mfg)		8,500	1
Anchor Continental Inc.	Columbia	SC		Toluene	120,000	12
Carolina Eastman	Columbia	SC	Terephthalic Acid Manufacture	Methyl Bromide	10,000	12,19
				Methyl Acetate		
				p-Xylene		
				Methanol		
				Acetaldehyde		
Hoechst Fibers Inc.	Spartanburg Co.	SC	Chemical Manufacture	Terephthalic Acid-HNO3-Paraxylengen	9,528	1
Dupont	Davidson Co.	TN	Polyester Production		1,711	1
Dupont	Davidson Co.	TN	Polyester Production		2,978	1
Schrader Automotive Products	Dickson	TN	Degreasing			1
R. R. Donnelley & Sons	Gallatin	TN	Gravure	Trichloroethylene	39,960	1
R. R. Donnelley & Sons	Gallatin	TN	Gravure		17,340	1
R. R. Donnelley & Sons	Gallatin	TN	Rotogravure		175,000	13
R. R. Donnelley & Sons	Gallatin	TN	Gravure		78,000	22
Alco Chem Corp	Hamilton Co.	TN	Chemical Manufacture Storage Tanks	Toluene		1
Velsicol Chem Corp	Hamilton Co.	TN	Chemical Manufacture (packaging)	DEA DBA	60	1
Velsicol Chem Corp	Hamilton Co.	TN	Chemical Manufacture (refining)	Benzoyl Chloride		1
Velsicol Chem Corp	Hamilton Co.	TN	Chemical Mfg (tank truck loading)	Benzoyl Chloride		1
Velsicol Chem Corp	Hamilton Co.	TN	Chemical Manufacture (storage)	Benzoyl Chloride		1
Tennessee Eastman Co.	Kingsport	TN	Acetone Production	Acetone	25,080	1
Tennessee Eastman Co.	Kingsport	TN	Chemical Manufacture	Acetone	12,000	1
Tennessee Eastman Co.	Kingsport	TN	Textile Production		423	1
Tennessee Eastman Co.	Kingsport	TN	Chemical Manufacture	Acetone	16,020	1
Tennessee Eastman Co.	Kingsport	TN	Chemical Manufacture		16,500	1

(Continued)

TABLE 1 (Continued)

COMPANY	CITY/COUNTY	ST	SOURCE	CHEMICAL	FLOW (CFH)	REF
Tennessee Eastman Co.	Kingsport	TN		Acetone	15,000	12
Tennessee Eastman Co.	Kingsport	TN		Acetaldehyde, Diethylether	5,000	12
Tennessee Eastman Co.	Kingsport	TN		Acetaldehyde	5,000	12
IBM Corp	Austin	TX	Circuit Board Manufacture			8
Texas Instruments Inc.	Austin	TX	Printed Wire Manufacture	Methyl Chloroform,	2	8
				Methyl Chloride		
Dupont	Beaumont	TX	Hypalon Process	Chloroform,	146	8
				Carbon Tetrachloride		
Velsicol Chemical Corp	Beaumont	TX	Benzoic Acid Manufacture			8
Celanese Plastics Co.	Bishop	TX	Nylon Production	1,6-Diaminodioxane/others		8
Brown & Root Inc	Corpus Christi	TX				10
Texas Color Printers Inc.	Dallas	TX				3
Diamond Shamrock	Deer Park	TX	Chemical Manufacture	Toluene, Naphtha, Xylene	61,000	17,26
Diamond Shamrock	Deer Park	TX	Ethylene Dichloride Manufacture	Trichloroethylene	0.49	8
Empak Inc.	Deer Park	TX	Railcar Cleaning	Acetylene, EDC		9
Saltex Polymer Corp	Deer Park	TX	Peroxide-Percarbonate of soda prod			8
Shell Oil Co.	Deer Park	TX	Phenol Production	Cumene, Formaldehyde,	17,980	18
				Methanol, Acetaldehyde		
Allen Bradley Co.	El Paso	TX	Potentiometer Manufacture	Trichloroethylene	1.7	8
				Methyl chloroform		
Allen Bradley Co.	El Paso	TX	Resistor Manufacture	Trichloroethylene		8
Robertshaw Controls Co.	El Paso	TX	Vapor Degreaser	Perchloroethylene		8
Texas Color Printers, Inc.	Farmers Branch	TX	Gravure Printing			8
Texas Color Printers, Inc.	Farmers Branch	TX	Gravure Printing			8
Diamond Shamrock	Fort Worth	TX				10
Tandy Magnetics	Fort Worth	TX	Gravure Coating			8
Dow Chemical	Freeport	TX	Isocyanate Production	Toluene Diisocyanate	10	8
Dow Chemical	Freeport	TX	Epoxy Resin Mfg	Halogenated compounds		8

(Continued)

TABLE 1 (Continued)

COMPANY	CITY/COUNTY	ST	SOURCE	CHEMICAL	FLOW (CFH)	REF
Dow Chemical	Freeport	TX	Phenol Production			1,8
Rhone-Poulenc Inc	Freeport	TX	Ethyl Vanillin Prod	Ethylene Dichloride		8
Skintech	Freeport	TX	Polyvinyl Chloride Manufacture	Vinyl chloride		8
Continental Oil	Grapevine	TX				10
Liquid Paper Corp.	Greenville	TX	Typewriter Ribbon, Correction Fluid			8
Armco Steel Corp.	Houston	TX	Coke Plant By-Products	Phenol	100	8
Maxwell House	Houston	TX	Caffeine Extraction		0.8	8
Maxwell House	Houston	TX	Decaffeination			8
Trumbull Asphalt Div. Owens Corning	Houston	TX	Petroleum Dehydration			8
Dominguez and Sapp Enterprises	LaMarque	TX	Tar Recovery	Vinyl chloride and other HCs		8
Continental Can Co.	Longview	TX	Can Manufacture			8
Longview Refining	Longview	TX	Light Oil Truck Loading			8
Western Electric	Mesquite	TX	Circuit Parts Cleaning	Perchloroethylene	5	8
Western Electric	Mesquite	TX		Perchloroethylene	4	8
Western Electric	Mesquite	TX	Backplane Connectors		1	8
Western Electric	Mesquite	TX		Perchloroethylene	5	8
Western Electric	Mesquite	TX	Circuit Parts Cleaning	Perchloroethylene	2.49	8
Western Electric	Mesquite	TX	Soldering			8
Illinois Tool Works Inc.	Mineral Wells	TX	Vapor Degreasing	Trichloroethylene	1.3	8
El Paso Products	Odessa	TX	Adipic Acid Production	Cyclohexane		9
Gulf Oil	Orange	TX				10
Hu Mor Chem Inc	Palacios	TX	Herbicide and Pesticide Mfg.†	Phosgene, Mercaptans		8
B. F. Goodrich	Pasadena	TX	Chemical Manufacture	Carbon Tetrachloride		8
Diamond Shamrock	Pasadena	TX	Chemical Manufacture			8
FMC	Pasadena	TX	Hydrogen Peroxide Prod			8
Tenneco Chemicals	Pasadena	TX	Polyvinyl Chloride Manufacture	Vinyl Chloride		8,9
Gulf Oil	Port Arthur	TX				10
Tessco	Port Arthur	TX	Petroleum loading/storage			8

(Continued)

TABLE 1 (Continued)

COMPANY	CITY/COUNTY	ST	SOURCE	CHEMICAL	FLOW (CFH)	REF
Kelly AFB (USAF)	San Antonio	TX	Aircraft Repair and Testing	Naphtha, Perchloroethylene		8
Sigmar Pipeline Corp	San Antonio	TX				10
Folger Coffee Co.	Sherman	TX	Coffee Processing			8
Lowry Tank and Terminal Co.	Texas City	TX	Chemical Storage			8
Texas City Refining Inc.	Texas City	TX				10
Union Carbide	Texas City	TX	Organic Acids Production			8
Union Carbide	Texas City	TX	Ethylene Amine Production	Vinyl Chloride, Dichloroethylene		9
Western Zirconium, Inc.	Waco	TX	Zirconium Sponge Separation		3	8
Utex Industries Inc.	Weimar	TX	Rubber packing, gaskets, and seals	Methyl ethyl ketone, toluene	10	8
Exxon Co.	Chesapeake	VA				10
Reynolds Metal Co.	Grotoes	VA			16,000	12
Meredith-Burda Inc.	Lynchburg	VA		Tetrahydrofuran	48,500	15,17
Meredith/Burda	Lynchburg	VA		Toluene	2,485	1
Celanese Fibers Co.	Narrows	VA	Gravure	Acetone	50,000	12
Stauffer Chemical Co.	Richmond	VA			3,000	15
FMC Corporation	Spotsylvania	VA	Film coating		32,200	1
Dupont	Waynesboro	VA	Plastics prod	Acetone		1
Kalams Chemical Co.	Kalama	WA	Benzoic Acid Manufacture	Toluene	6,250	16
Marathon Oil Co.	Milwaukee	WI				10
Phillips Petroleum	Milwaukee	WI				10
Husky Oil Co.	Cheyenne	WY				10

(Continued)

TABLE 2. REFERENCES FOR SURVEY OF VAPOR-PHASE APPLICATIONS OF
ADSORPTION LISTED IN TABLE 1

1. Barkau, Harold, Computer Search of National Emissions Data System, U.S. EPA, Research Triangle Park, NC, Oct. 2, 1979.
2. Bruckman, Leonard, Connecticut Report of Sources Using Activated Carbon Adsorption Devices, Oct. 12, 1979.
3. Montney, Wayne, State of Illinois EPA Surveillance Report Source Information, Oct. 1, 1979.
4. Kearney, Ken, Indiana State Board of Health, telephone conversation with F. D. Hobbs, Hydrosience, Inc., Sept. 14, 1979.
5. Louisiana State Emission Inventory Questionnaire, reviewed by F. D. Hobbs, Hydrosience, Inc.
6. Beale, J., Dow Chemical Company, letter to L. Evans, Emission Standards and Engineering Division, Office of Air Quality Planning and Standards, U.S. EPA, Research Triangle Park, NC, March 14, 1978.
7. Naperkoski, C., Ohio EPA, letter to F. D. Hobbs, Hydrosience, Sept. 28, 1979.
8. Thomas, R., Texas Air Control Board, Searches of State of Texas Permit File, Sept. 5, 1979 and Oct. 23, 1979.
9. State of Texas Emission inventory questionnaire, reviewed May and June 1977 by F. D. Hobbs, Hydrosience, Inc.
10. Goble, Mack, Goble and Brown Inc., list of clients using adsorption units made by HydroTech Engineering Division, Aug. 20, 1979.
11. Vistica, E. A., Witco Chemical, letter to D. R. Goodwin, U.S. EPA, Feb. 6, 1978.

12. Vulcan Manufacturing Co., Cincinnati, Ohio, partial listing of clients, July 1977.
13. Alton, P., American Ceca Corp., Solvent Recovery Division, telephone call to F. D. Hobbs, Hydrosience, Inc., Aug. 30, 1979.
14. Konter, P., Minnesota Air Control Board, telephone call to F. D. Hobbs, Hydrosience, Inc., Sept. 14, 1979.
15. Graphic Arts Emission Test Report at Meredith-Burda, Inc., EPA Report 79-GRA-1, March 1979.
16. Southwest Air Pollution Control Authority, application for approval, Vancouver, Washington, Oct. 31, 1973.
17. Reich, R. A., Radian Corporation, letter to F. D. Hobbs, Hydrosience, Inc., Sept. 12, 1979.
18. Shell Oil Company/Shell Chemical Co., Deer Park, TX, Texas Air Control Board Permit Application for Phenol-2 as revised May 9, 1975.
19. Dylewski, S. W., Hydrosience, Inc., Trip Report for Visit to Hercofina, Wilmington, NC, Nov. 17, 18, 1977 (data on file at EPA, ESED, Research Triangle Park, NC).
20. Warland, R. K., New York Department of Environmental Conservation, New York State Air Pollution Source Management System Facility/EP Data List, July 19, 1979.
21. Chemical Engineering, Vol. 85 No. 10, April 24, 1978, p. 115.
22. Thomas, Larry, Environmental Systems, Union Carbide Corporation, telephone conversation with C. S. Parmele, Hydrosience, Inc., December 1979.
23. Demonstration of Carbon Adsorption Technology for Petroleum Dry Cleaning Plants (contractor's draft report), U.S. EPA, IERL, Cincinnati, Ohio, April 1979.

24. Maleic Anhydride Product Report, Emissions Control Options for the Synthetic Organic Chemicals Manufacturing Industry (EPA Contract No. 68-02-2577), March 1978.
25. Likens, Merle, Standard Gravure Corporation, Plant tour during Gravure Research Institute/Gravure Technical Association Seminar on Emission Control, Louisville, KY, Sept. 25, 1979.
26. Graphic Arts Emission Test Report at Texas Color Printers, Inc., draft report prepared for EPA by Monsanto Research Corporation.
27. USS Polyester, Colton, CA, plant personnel, September 1979.
28. Larson, W. E., Chevron U.S.A., Inc., letter to D. Barton, September 4, 1979.
29. Cascade Cleaners, Los Angeles, CA, plant personnel, September 1979.
30. Am Vac Chemical Corporation, Los Angeles, CA, plant personnel, September 1979.
31. Factory Apron & Towel Supply, Inc., Los Angeles, CA, plant personnel, September 1979.
32. Stauffer Chemical Co., Richmond (Stege), CA, plant personnel, September 1979.
33. Chase, Emil, Movie Lab, Hollywood, CA, September 1979.
34. Lang, W., General Tire and Rubber Co., telephone conversation with C. S. Parmele, Oct. 5, 1979.

they should be verified because the data were often based on unconfirmed engineering estimates. Since the significant followup required to develop and validate these data could not be done within the budgetary constraints of this project, it was not worthwhile to evaluate any of these data. It was also not worthwhile to compare the results of this survey with the work of other EPA contractors who have assessed the use of adsorption in specific industries such as dry cleaning or metal degreasing.

Several people contacted referred to a master list of control devices which would be able to identify all of the applications of adsorption. If such a listing exists, it was not found by this survey despite numerous attempts to followup these leads. These followup activities always had two results. Either the data source was not as comprehensive as reported or else nobody who knew about the source of data could be located.

Compiling a data base to assess the effectiveness of adsorption does not require the collection of data for all the applications listed in Table 1. Table 1 can be used, however, to set priorities for additional followup activities by identifying the applications for which more data are desired.

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APPENDIX A

SUMMARY OF CONTACTS MADE

The following is a summary of the sources surveyed including the names and phone numbers of the people who provided information. This discussion is included to expedite followup activities by taking advantage of the effort that has already been expended to first identify the people within the various agencies who know if the data exist and if so how to access it.

1. Carbon-Adsorption Vendors

Eight equipment and/or carbon suppliers were contacted in a telephone survey and requested to provide information (one vendor, Phillips Pollution Control Systems, could not be located). One vendor, American Ceca, gave some information on eight installations in the initial telephone contact. Two vendors, Vulcan and Hydrotech, provided a partial listing of clients and their locations. Hoyt, Ray-Solv, Oxy-Catalyst, Calgon, and VIC Manufacturing stated they were unable to provide assistance either because of confidentiality problems with disseminating client information or because there was no economic incentive for them to give assistance.

Contacts

American CECA Corp. Solvent Recovery Div., P. Alton (312)986-1515

Vulcan Manufacturing Co., Robert Duhl (513)281-2800

Hydrotech Engineering, Inc., Mac Goble (713)780-4448

Hoyt Manufacturing Corp., D. W. Oakes (617)636-8811

Ray-Solv, Inc., Robert Spencer (201)981-0500

VIC Manufacturing Co., Tom Cannon (612)781-6601

Calgon Corporation, Roger Zanitsch (412)777-8424

Oxy-Catalyst, Robert Kenson (215)692-3500

2. Professional Societies

Two were contacted. The Society of Plastics Industry stated no records were maintained on control devices used by member companies. The Gravure Research Institute referred us to Radian Corp., which provided a report listing rotogravure companies, locations, and whether or not carbon was being used.

Contacts

Society of Plastics Industry, John Lawrence (212)573-9400

The Gravure Research Institute, Harvey George (516)883-6670

3. EPA Regions

Regions III, IV, V, VI, and X were contacted and practically no information was obtained even after as many as six people per region were questioned. One region (VI) did perform a NEDS (National Emissions Data System) data search for Louisiana and Texas, which located only one carbon system.

Contacts:

Region III, William Bellanger (215)597-8188

Region IV, Barry Gilbert (404)881-2864

Region V, Eric Cohen (312)353-2090

Region VI, Tim Matzke (214)767-2541

Region X, referred us to Washington State, Ed Taylor (206)696-2508

4. EPA - Data Analysis System National Air Data Branch, Office of Air Quality Planning and Standards

A search for carbon adsorption control devices listed in NEDS was received. This search identified 128 applications. The failing of NEDS is that many states have an upper emissions limit which must be exceeded before the data are reported to the national NEDS. Therefore, NEDS is only as complete and accurate as the information supplied by the states.

Contact:

Harold Barkau (919)541-5491

5. EPA - Standards Development Branch Emissions Standards and Engineering Division Official Air Quality and Performance Standards, Research Triangle Park, NC

There are data on adsorption applications in their files but not in one central location. This is one source that should be included in any followup activities. Reports on adsorption as a control device in the dry cleaning industry were also provided.

Contact:

Dave Patrick (919)541-5477

6. EPA - Washington, DC

Compliance Data System traces Stationary Sources and Enforcement Actions pertaining to air pollution violations. This is a computerized data system but could not provide any data for this survey because carbon adsorption as a control device is not included in this data bank.

Contact:

Franklin Smith (202)755-0103

7. States

Wisconsin, Michigan, Missouri, Virginia, New Jersey and Pennsylvania had no ready method for performing a search although New Jersey is planning to establish a computerized data base in the near future. West Virginia provided a listing of chemical companies which they said could be contacted individually. Indiana, California, Ohio, and Washington performed manual searches of their files and provided some data. Computerized searches were performed by Connecticut, Illinois, Texas, Minnesota, and New York. Maryland offered transfer of entire state emissions file to our tape, but we did not follow up because of the large amount of effort required. The contacts made with the various states are summarized in Table A-1.

The biggest difficulty with surveying the states is, first of all, locating the section that might have files describing control devices (compliance, enforcement, permits, etc). The second problem is validity of the data. For example, permit data generally are based on engineering estimates. Also, permit files may represent facilities which were never completed. Illinois suggested the data from users and installations should be individually validated prior to use. Validation of data from other sources would also be appropriate. There was insufficient time for such a validation program.

8. Miscellaneous

Information that had been compiled for Hydrosience's contract with Emission Standards and Engineering Division, Office of Air Quality Planning and Standards, US EPA, Research Triangle Park, NC (Contract No. 68-02-2577), was reviewed. This included Product Reports, Trip Reports, and Emission Inventory Questionnaires for Louisiana and Texas. Only a small percentage of the applications in Table 1 were identified by this review.

A search of the open literature via the Lockheed Dialog System revealed that very little information has been published for full-scale applications of vapor-phase adsorption.